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A SILVICULTURAL GUIDE FOR THE WHITE PINE AND RED PINE WORKING GROUPS IN ONTARIO

Ontario
Ministry of Natural Resources
Lyn McLeod
Minister

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Ontario

A SILVICULTURAL GUIDE FOR THE WHITE PINE AND RED PINE WORKING GROUPS IN ONTARIO

1989
Forest Resources Group

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FOREWORD

This silvicultural guide is one of several that are published as part of the Ontario Ministry of Natural Resources Science and Technology Series on forestry.

Each silvicultural guide provides a description of the silvicultural characteristics of the working group[1] species and describes silvicultural practices for the working group. The guide reflects relevant literature and research, but equally important, the knowledge and experience of forestry staff in the management of the working group in Ontario and elsewhere.

The guides are primarily for use at the management unit level, where they are intended to be adapted and interpreted to meet local objectives and conditions. In particular, they are to be used by the management forester as a source of information and data that, together with local knowledge and experience, must form the basis for the development of silvicultural prescriptions in the timber management planning process.

George Tough
Deputy Minister

[1] Working group: An aggregate of forest stands that have the same predominant species (Ontario Ministry of Natural Resources [OMNR], Forest Resources Branch Policy No. FR 15 01 01 PO [1988], *Working Groups*).

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INTRODUCTION

White pine and red pine are inextricably linked to Ontario's history. The sale of pine square timber to Britain in the 1800s and pine sawtimber to the United States in the late 1800s and early 1900s provided impetus and revenues for the colonization and development of early industrial Ontario (Aird 1983). In 1984, white pine was proclaimed the provincial arboreal emblem to honour its contribution to Ontario's history (OMNR 1984).

Both pines, but especially red pine, have also played significant roles in the reclamation of severely eroded agricultural land in southern Ontario earlier this century. The many pine plantations established throughout this area attest to this fact (Borczon 1986).

Manufactured wood products of white pine and red pine have consistently been in strong demand domestically and internationally, and raw- and manufactured-product prices are high compared to other species. White pine and red pine also enhance other resource values, including recreation and wildlife. Effective timber management is needed to sustain the white pine and red pine resource and to maintain other values.

This guide deals primarily with the management of even-aged stands in the white pine and red pine working groups throughout their entire life from harvest and renewal to the end of the rotation. White pine and red pine are the principal commercial species in these working groups; the management of both species is addressed. These two species commonly occur together in natural stands and share similarities in their silvics, growth characteristics, and economic importance. At the same time, these species differ in many respects, and unless their particular requirements and growth characteristics are understood, effective management of these species, together or separately, will not be possible.

This guide emphasizes the management of a stand as an integrated and interdependent series of treatments, including harvest, renewal, and maintenance operations. Local differences in environmental, economic, social, and other factors occur and must be considered when timber management plans are developed.

The main purposes of this guide are to summarize the knowledge of the silvics of white pine and red pine; to describe the current timber management practices for white pine and red pine in Ontario; to identify important factors that the manager must consider during the development of the timber management plan and site-specific prescriptions; and to provide a basis for subsequent developments in both knowledge and practice. Although this guide was developed for the area of the province comprising officially designated Crown Management Units, the principles outlined herein may be applied elsewhere.

This guide is intended to be used as a reference document. A list of pertinent literature is provided in the "References Cited" section. This list can be consulted when further details concerning a particular topic are required.

1.0 MANAGEMENT OBJECTIVES

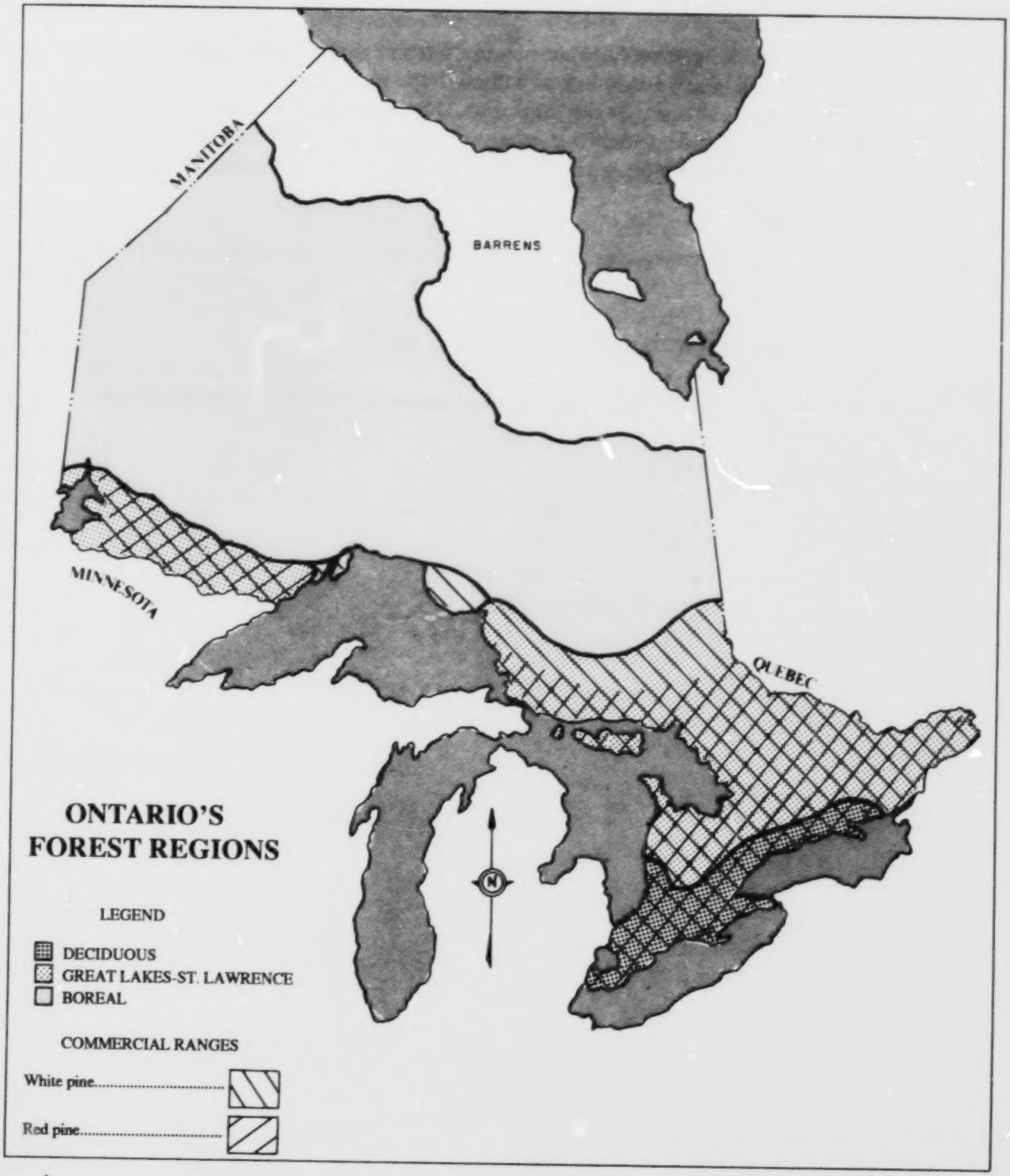
The management objectives for the working group of any forest depend upon the nature of the forest, the nature of the demand and market for forest products, and the requirements of the Ontario Ministry of Natural Resources (OMNR), which represent the public owners.

The purpose of timber management for white pine and red pine in Ontario is to provide a supply of forest products to Ontario's forest industry through the management of the two working groups on a sustained yield basis. At the same time, the OMNR is committed to a policy of integrated resource management such that other uses and users, particularly of non-timber values, are taken into account in timber management planning and in the implementation of non-timber management practices.

Specific objectives for the management of the white pine and red pine working groups are as follows:

- to maintain the genetic integrity of the resource; and
- to maintain or enhance the present volume of growing stock to provide high value sawlogs and poles for the forest industry.

Figure 1: Commercial ranges of white pine and red pine in Ontario (adapted from Haddow [1948]; Fraser [1953]; Boughner [1964]; and Rowe [1972])



2.0 CHARACTERISTICS OF THE WHITE PINE AND RED PINE WORKING GROUPS

In Ontario, white pine and red pine are classified separately into working groups for inventory purposes (OMNR 1978), although they grow in close association and many stands contain both species. Stand differences can be accommodated by the subdivision of working groups into forest units[1] during the management planning process. For example, pure and mixedwood pine stands may be separated when it is appropriate to employ different silvicultural systems for these two stand types.

Concentrations of pure, or relatively pure, stands of white pine occur in the OMNR districts of Parry Sound, Algonquin Park, and Temagami. In other parts of Ontario, white pine and red pine more commonly form mixedwood stands with a hardwood component of up to 30 to 60 per cent.

The range and commercial importance of white pine and red pine are outlined in this section. In addition, physical features of the environment where the pines grow and important biological characteristics of the two species are presented. Other factors, including wildlife and environmental considerations, are discussed in relation to timber management. This information provides the foundation for the development of site-specific silvicultural prescriptions.

2.1 Range and Commercial Importance

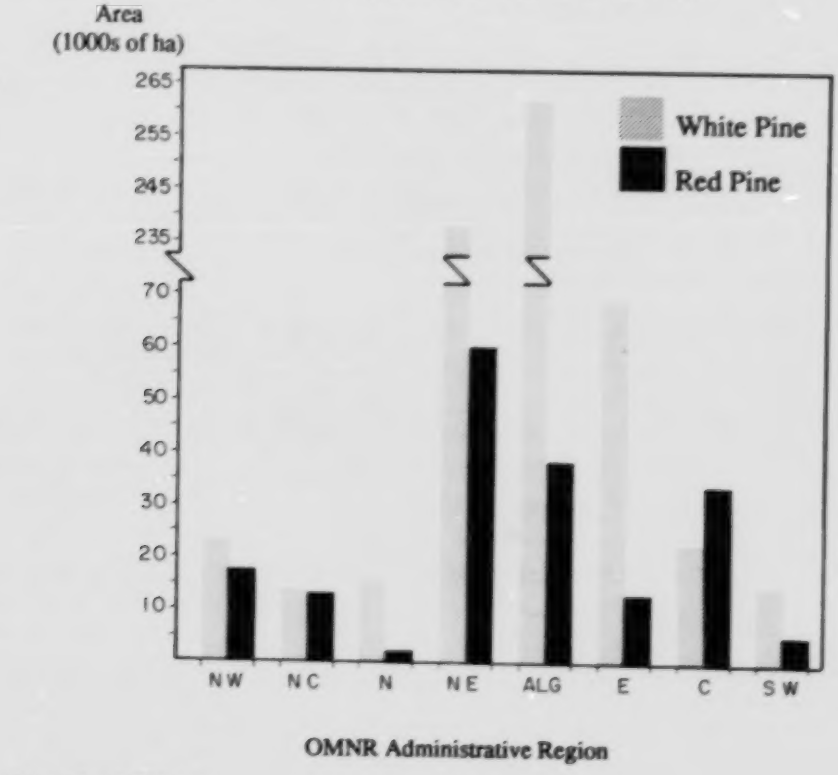
Commercial range refers to that area where white pine and red pine attain suitable stem size, condition, and stand volume for commercial harvest using current technology. In Ontario, the commercial ranges of white pine and red pine (Figure 1) are largely confined to the Great Lakes-St. Lawrence and Deciduous Forest Regions (Rowe 1972).

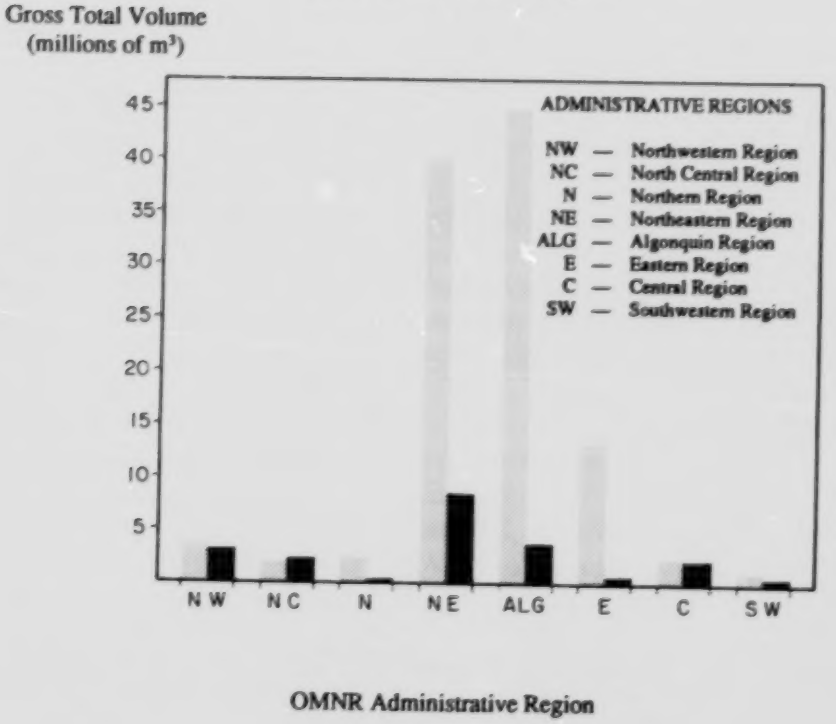
The extensive logging of white pine and red pine stands during the 1800s and the changes in fire frequency over their ranges during the past century have affected the distribution and abundance of these two species. As a result, large areas that were once occupied by white pine and red pine have converted naturally to poplar, birch, spruce, and balsam fir. In northern Ontario, the abundance of commercial white pine has decreased because of high incidences of white pine blister rust. The ranges of both pines, but especially red pine, have been extended throughout southern Ontario by the establishment of plantations of these species on lands unsuitable for agriculture.

White pine and red pine represent three per cent and one-half per cent, respectively, of the conifer growing stock in Ontario (OMNR 1986f). Regionally, however, these species have a much greater significance. For example, white pine and red pine represent 44 and 4 per cent, respectively, of the conifer growing stock in the Algonquin Region. The estimated growing stock, by area and volume, in the white pine and red pine working groups is presented by OMNR

[1] Forest Unit: Any aggregate of forest stands managed under the same silvicultural system and rotation (OMNR, Forest Resources Branch Policy No. FR 15 02 01 PO [1988], *Forest Units*).

Figure 2: Area and volume of growing stock in the white pine and red pine working groups by OMNR Administrative Region (from OMNR [1986f])





Administrative Region in Figure 2. In addition, it should be noted that a considerable volume of white pine occurs in other working groups and a significant portion of the present white pine harvest comes from these stands.

For production forest land, approximately 86 per cent of the white pine working group and 61 per cent of the red pine working group are located in the Northeastern, Algonquin, and Eastern Regions combined. The age-class distribution of the white pine and red pine working groups in these three regions is presented in Appendix I.

The harvest of white pine and red pine in Ontario has remained relatively stable for almost 60 years at approximately 800 000 m^3 per year (Aird 1983). This harvest information is displayed graphically in Appendix II. The primary market, sawtimber, has been little affected by economic forces and thus is less cyclical than for fibre products such as pulp and paper (Caldwell 1978; Aird 1983; Schumann 1985). The wood qualities of white pine (e.g., fine grain, durability, and stability) make this species well-suited to a variety of industrial and domestic construction applications. Red pine wood has qualities very similar to white pine, except that it is heavier and harder, with a corresponding improvement in mechanical qualities (Aird 1983). As a result, red pine is in demand for applications where greater mechanical strength is required (e.g., utility poles).

During 1982 to 1986, white pine and red pine constituted 44 per cent of the softwood lumber recovery for those mills in Ontario that processed these two species. However, for some mills, white pine and red pine represented the prime source of raw material. Production was concentrated in the Northeastern and Algonquin Regions, with 84 per cent of white pine and red pine lumber coming from mills in these two regions (Figure 3).[2]

In the Northeastern Region, approximately 85 per cent of the roundwood delivered to mills came from Ontario Crown lands, with the balance coming from other sources; the estimate is 60 per cent for the Algonquin Region. Appendix III contains a visual representation of these data.

Generally, the domestic and international demand for medium- and high-quality white pine timber is strong. This demand is expected to increase with strengthening international markets (Schumann 1985). Since the supply of good-quality white pine timber is limited throughout its range, prices of mill-delivered logs and manufactured products are expected to increase. The price for mill-delivered logs of white pine and red pine is high and is exceeded by few other species, primarily hardwoods.[3] Mill-processing costs for pine logs of all grades are relatively constant and are significantly lower than for hardwood logs. In addition, the price differential between the mill-end product of grade one white pine logs is about four times that for lower grade logs.[4] White pine in particular has excellent value-added potential (Robbins 1985).

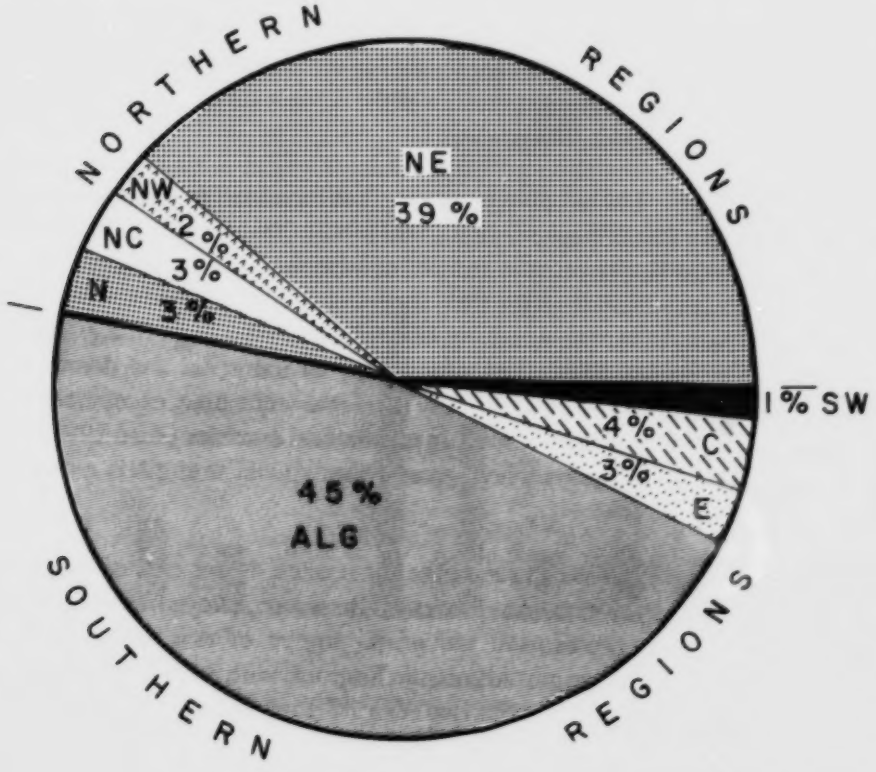
Many jobs in Ontario depend directly or indirectly on the white pine and red pine resource. In the future, markets for products with a high value-added component may increase significantly

[2] The information contained in this paragraph and the following one was derived from individual mill statistics, Timber Sales Branch, OMNR, Toronto.

[3] Johnson, D., Chief Forester, G.W. Marten Logging Ltd., Harcourt, Ontario, Personal Communication.

[4] Information provided by Murray Brothers Lumber Company Limited, Madawaska, Ontario.

Figure 3: Average annual lumber production of white pine and red pine for the period 1982 to 1986 by OMNR Administrative Region, (derived from individual mill statistics [1987] Timber Sales Branch, OMNR)



(Engalichev 1985). To maximize the economic potential of the pine resource, better utilization of small-dimension and lower-grade logs is required. To this end, Forintek Incorporated is engaged in the development of technology that would permit the manufacture of quality products from lower-grade logs.

In addition to their commercial timber value, the cultural, recreational, and wildlife values of white pine and red pine are also important. While these values are largely intangible in terms of economics, they remain very significant locally.

2.2 Site

Site refers to all the biotic and abiotic factors of the environment and can be classified qualitatively into site types by climate, soils, and vegetation (adapted from Ford-Robertson and Winters [1977]). Knowledge of the tolerance that a species exhibits to environmental factors is fundamental to the development of site-specific silvicultural prescriptions. This includes the selection of an appropriate level of management intensity and thus silvicultural investment.

2.2.1 Climate

The commercial ranges of the white pine and red pine working groups embrace considerable climatic diversity. Pertinent macroclimatic data for northern and southern Ontario are summarized in Table 1. The climate in southern and northwestern Ontario is characterized by warm, dry summers. The spring and summer period is often very dry, particularly in southeastern and northwestern Ontario. In comparison, the climate of central and northeastern Ontario is characterized by cooler, moister conditions brought about by the moderating influence of the Great Lakes.

The northern botanical range of both pines closely parallels the 2°C mean annual isotherm (Haddow 1948). White pine is restricted in the north to areas where the mean frost-free season is above 833 degree-days Celsius (Boughner 1964). The northern botanical limit of red pine is related to a deficiency of summer heat (Fraser 1953).

"Local climate can both extend and restrict the survival and growth of white pine and red pine" (Stiell 1978). Both pines are susceptible to frost damage on low-lying sites where cool air collects, and on open, dry, sandy outwash plains, where night radiation promotes rapid cooling (Horton and Bedell 1960). Frost damage is greatest when the foliage first flushes in the spring, but cotyledonous seedlings may be affected throughout the growing season or in the fall. Damage is characterized by dead growth tips, resulting in deformity or, in extreme cases, death of seedlings.

Low-lying areas or depressions accumulate cool, moist air. This climatic condition favours the development of diseases, particularly white pine blister rust and scleroderris canker (Morse 1981; Schone et al. 1984).

White pine is more sensitive to moisture stress than red pine is (Horton and Brown 1960; Stiell 1978), but moisture stress can be very damaging to both species during the seedling stage. A minimum of 10 cm of precipitation during the early summer period is required for the germination and early growth of red pine seedlings. Soil and air temperatures of more than 33°C will significantly lower the germination and early growth potential of white pine and red pine (Horton and Bedell 1960).

"Sunscald can damage the thin bark of young white pine" (Stiell 1978). Stands that are released or thinned and growing on sites subject to periodic high temperatures (e.g., south-facing slopes), are particularly susceptible. Snow and ice can cause breakage of branches in young stands of either species. Ice storms and sleet can cause top breakage and permanent bending of red pine, especially in dense stands where thinnings have been delayed. This type of breakage causes considerable splintering below the break. White pine and red pine exhibit deep rooting on unstratified soils; except for older trees or those with root rot, neither species is particularly subject to windthrow (Stiell 1978). On shallow sites, white pine is less susceptible to windthrow than red pine is.

Climatograms showing 30-year averages for numerous climatic parameters have been prepared

TABLE 1: Regional Climatic Data for the Commercial Ranges of the White Pine and Red Pine Working Groups in Ontario*

Climatic Parameter	Northern Ontario	Southern Ontario
Altitude (metres above sea level)	180 - 425	120 - 490
Mean date of last frost in spring	May 31 - June 10	May 1 - May 31
Mean date of first frost in fall	Sept 7 - Sept 20	Sept 10 - Oct 8
Mean annual precipitation (cm)	66 - 86	66 - 102
Mean May to September precipitation (cm)	38 - 41	33 - 38
Mean annual temperature (°C)	2 - 5	5 - 7
Mean annual frost-free days	96 - 112	100 - 170

*Adapted from Chapman and Thomas (1968) and Brown et al. (1974)

for stations throughout Ontario (MacIver 1986) for four modal soil textures (sand, sandy loam, clay loam, and clay). The climatograms may be useful when developing silvicultural prescriptions.

2.2.2. Soils

For the purposes of this guide, soil classification follows the system outlined in *The Canadian System of Soil Classification* (Canada Soil Survey Committee 1987). Standard methods for describing soils attributes are contained in *Canadian Soil Information System Manual for Describing Soils in the Field* (Expert Committee on Soil Survey 1983). The Ontario Institute of Pedology at Guelph has produced a guide, *Field Manual for Describing Soils*, based on the above (OIP 1985).

Moisture regime, texture, and available rooting volume are the most important soil factors affecting the timber production potential of white pine and red pine. Soil nutrient regime and soil

alkalinity are secondary factors of importance. An edaphic grid showing the range of soil moisture and soil nutrient regimes suitable for commercial timber production of white pine and red pine is provided in Figure 4. The Northeastern Region has been involved in a project for the past several years to classify timber productivity potential for various species in relation to soil moisture, texture, and depth. The results of these studies for white pine and red pine in Site Region 5200 are summarized in Figure 5.

Moisture Regime

White pine achieves best growth on well drained fresh to moderately moist soils (Stiell 1978), while red pine performs best on well to moderately well drained fresh to very fresh soils (OMNR 1986d). White pine tolerates a wider range of soil moisture conditions than red pine does, especially wetter soils (Horton and Bedell 1960).

White pine is less drought-resistant than red pine is and shows poorer performance on dry sites (Shirley 1943; OMNR 1983; Taylor and Jones 1986). Red pine grows poorly on moist soils because of poor soil aeration (Stone et al. 1954; Dreisinger et al. 1958; Stiell 1978). The growth of both pines is reduced on very dry, very moist, and wet sites (Horton and Bedell 1960; OMNR 1983; Taylor and Jones 1986).

Texture

White pine is highly productive on fine sands, sandy loams, loams, and silt loams, provided that soil moisture is not limiting (Taylor and Jones 1986). Moderate productivity is achieved on coarse sands and fine textured soils, including clay loams and clays. Poorly structured clays are less productive because they have a limited recharge capacity after drying. In the Northeastern Region, growth often commences before these soils thaw out and this process results in moisture stress. White pine productivity decreases along a south-north climatic gradient. This trend is more pronounced on the poorer sites (e.g., dry sands) in the northern part of its range.[5]

The best growth of red pine occurs on deep, well drained, fine sands and loams (Taylor and Jones 1986). The species is also well adapted to coarse sandy soils with an unrestricted rooting depth and good soil aeration (DeMent and Stone 1968). The growth of red pine is poor on clay loam and clay soils that have a weakly developed structure.

Coarse to medium sands containing bands of fine textured material within two metres of the soil surface can be very productive for the growth of both pines (Horton and Bedell 1960; Hannah 1969). These bands improve the moisture-holding capacity of the soil, thus improving productivity (White and Wood 1958).

---

[5] Heikurinen, J., Consultant (formerly Regional Forestry Specialist, Northeastern Region, OMNR), Sudbury, Ontario, Personal Communication.

Figure 4: Range of soil moisture and soil nutrient regimes suitable for the production of white pine and red pine timber in Ontario

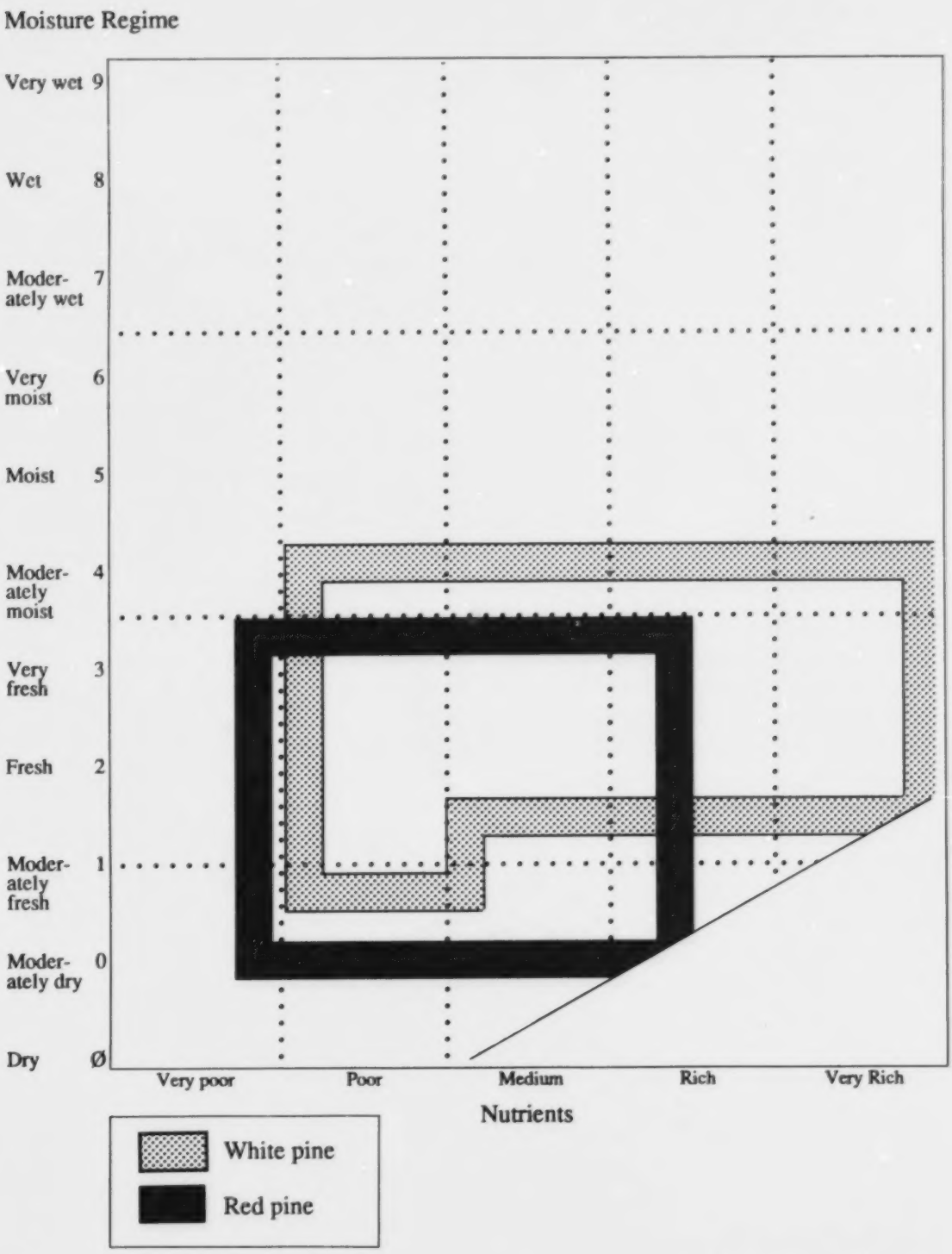
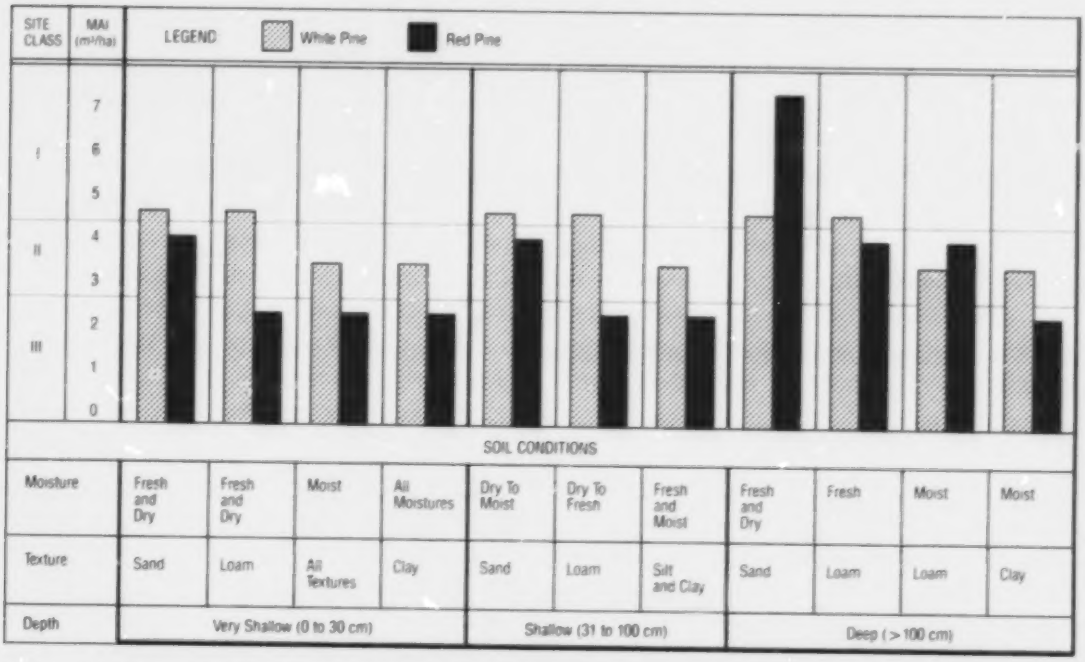


Figure 5: Timber production potential of white pine and red pine in relation to soil moisture, soil texture, and soil depth for Site Region 5200 in the Northeastern Region (derived from information contained in Kershaw [1988])



* These site classes are based on height over age calculated from trees of mean basal area. They are not equivalent to Plonski's (1981) site classes

^ MAI = mean annual increment (m^3/ha)

' There is considerable variation in the productivity potential within the shallow depth class, especially in the 31 to 60 cm range

Rooting Volume

Height growth and vigour of both pines frequently drop where obstructions to rooting occur within 60 cm of the soil surface (OMNR 1983; Taylor and Jones 1986). White pine, however, has a greater capacity to exploit shallow soils or soils of variable depth (Horton and Bedell 1960). On deeper soils, growth is influenced more by the chemical and physical properties of the site. Obstructions that restrict root growth include bedrock, compacted tills, hardpan, and shallow depth to distinct mottles. Smaller rooting volumes can reduce the amount of moisture, and thus nutrients, available for tree growth.

Chemical Properties

Both species grow well on soils of moderate to low fertility (Horton and Brown 1960), although white pine is more demanding than red pine is (Wilde et al. 1965). They both achieve good growth on nutrient-rich soils, provided that vegetative competition for light, moisture, and space is controlled (Horton and Brown 1960; Stiell 1978). For red pine, potassium and magnesium

deficiencies have occasionally been encountered on coarse sandy soils that had previously been under cultivation or had been severely burned (Lafond 1954; Horton and Brown 1960; Armson et al. 1975).

The optimum pH range for white pine is 4.7 to 7.3; for red pine it is 5.2 to 6.5 (Wilde 1966). Horton and Brown (1960) reported satisfactory growth for both species on soils with a surface pH as low as 4.0. White pine and red pine height growth and vigour frequently decline where free carbonates are located within 60 cm of the soil surface (Taylor and Jones 1986). Growth is not significantly affected when free carbonates occur at greater depths. Red pine grows poorly on soils derived from calcareous materials, but white pine attains satisfactory levels of growth on these soils.

2.2.3 Vegetation Communities and Succession

Both white pine and red pine are fire-climax or subclimax species (Maissurow 1935; Candy 1939; Horton and Bedell 1960; Methven 1973; Day and Woods 1977a,b). Regeneration in nature is largely dependant on disturbance, usually fire, coupled with a seed supply. Disturbance creates favourable conditions for the germination and establishment of the pines. In particular, the abundance and vigour of competing vegetation are reduced for several years, providing the pines with the opportunity to become established. Since red pine is very sensitive to competition, it usually enters as a pioneer or early successional species when understory trees and shrubs are not abundant. White pine is more tolerant of competition and thus may be represented in subclimax and climax vegetation communities growing on moist sites (Ahlgren 1976). The abundance of both white pine and red pine tends to decrease as sites become more moist, with red pine being most restricted. On these sites, disturbances other than fire (e.g., wind and disease) are responsible for the maintenance of some white pine in the stand (Nichols 1935). Both white pine and red pine are very long lived, a factor that has favoured their retention in areas of infrequent disturbance.

Pioneer tree species, including trembling aspen, largetooth aspen, and white birch, are well adapted to post-disturbance conditions, reproducing vegetatively over a large range of sites (Ahlgren 1976). These species are common associates of white pine and red pine on many sites, and will replace the pines where a pine seed source is lacking. Jack pine and red oak are common associates of white pine and red pine on very dry sites. Balsam fir, white spruce, and tolerant hardwoods are common associates of white pine on fresh to moist sites. These species have less demanding requirements for establishment than white pine and red pine have and they enter succession in the middle to late stages.

After disturbance, the diversity of vegetation communities on sites occupied by white pine and red pine increases; it then declines in later successional stages (Auclair and Goff 1971). Species intolerant of competition will decline in abundance and may be eliminated entirely on some sites.

The relative abundance, diversity, and vigour of understory vegetation varies with changes in edaphic factors, species tolerance, the stage of succession, and the intensity and frequency of

disturbance (e.g., fire, logging). Mosses and herbs are prevalent on dry, nutrient-poor sites. Shrubs and shade tolerant tree species increase in abundance and vigour as sites become more moist and nutrient-rich. Vegetation associations are described in greater detail in section 2.2.4, "Predominant Site Types."

2.2.4 Predominant Site Types

In this section, climate, soils, vegetation communities, and other aspects of site are combined into four recognizable predominant site types based on landform: outwash plains, dumped (ablation) till over bedrock, dumped till over moulded till, and lacustrine deposits. These landforms are described in detail in *The Physiography of Southern Ontario* (Chapman and Putnam 1984) and can be related to the pine associations and site classifications described in Horton and Bedell's (1960) *White Pine and Red Pine: Ecology, Silviculture and Management* and Scott's (1983) *A Silvicultural Guide to the White Pine Working Group in Ontario*. The landform classification system can be broadly related to site productivity and operational considerations such as the nature of the topography and intensity of management appropriate for successful renewal. It provides a useful framework for the development of site-specific silvicultural ground rules for timber management planning in Ontario.

A number of more detailed site or soil classification systems are under development across the commercial ranges of the white pine and red pine working groups. These classification systems include Forest Land Productivity Survey (FLaPS) in the Northeastern Region; Algonquin Site Program; and Ontario Soil Survey conducted by the Ontario Institute of Pedology. This work has shown that deep till and outwash sand deposits have a high production potential for both species. Shallow till over bedrock sites and lacustrine sites where the soil texture is clay loam or clay have a significantly lower production potential for both species. Similar productivity trends are expected in other parts of the province not covered by these classification systems. A complete list of site classification systems and other soils information is summarized in *Catalogue of Land Resource Surveys in Ontario of Major Value in Forest Management* (Pierpoint and Uhlig 1985).

Outwash Plains

Outwash plains are generally flat. Soils are usually deep, with a moisture regime ranging from moderately dry to moderately moist; they are usually sandy and may be underlain by discontinuous bands of finer and/or coarser material. Outwash plains may also be underlain by till deposits or lacustrine deposits. These bands and underlying deposits can have a significant effect on the timber production potential of the site. Depth of organic matter is greatest on fresh to moist sites where there is a high conifer component in the stand.

Both white pine and red pine occur in relatively pure stands on outwash plains, especially on the drier sites, with red pine predominating on coarser textured sands. Aspen and white birch grow in association with the pines but do not offer the same degree of competition here as they do on richer sites. In the northern part of its range, white pine can persist in the spruce-fir climax communities, but red pine tends to fall out (Scott 1983).

The abundance, diversity, and vigour of ground vegetation varies with moisture regime. Moist soils of moderate fertility support the richest communities. Aster, wintergreen, beaked hazel, red maple, and balsam fir are common associates on the more moist sites. Examples of dry-site vegetation include bracken fern, blueberry, and sweet fern. Productivity on this site type approximates Plonski's (1981) site class 1 or 2 for both pines.

Dumped (Ablation) Till over Bedrock

The topography of this landform varies from flat to hilly. In areas of the Precambrian Shield, the landform grades into steep, broken topography. Shallow soils are prevalent on ridges, with deeper deposits occurring on slopes and in depressions. The prevailing soil texture is sand (e.g., silty very fine sand and loamy sand). The soil moisture regime varies from dry to moist depending on slope position and depth to bedrock. Higher accumulations of soil organic matter are associated with fresh to moist soils where there is a relatively high conifer component. The prevailing microclimate ranges from warm and dry on ridges and upper south-facing slopes, to cool and moist on north-facing slopes.

Both white pine and red pine are most abundant on ridge tops and on south-facing slopes where conditions favouring wildfire occur. Red pine, and to a lesser extent white pine, exhibits poor growth where rooting volume is restricted by shallow depth to an impervious layer or by excess soil moisture.

White pine and red pine grow in association with aspen and white birch (which provide more competition here than on outwash plains) and with red oak; the abundance of these species varies with slope position. Balsam fir, red maple, and tolerant hardwoods are common associates on north-facing slopes. Pockets of pure white pine or red pine can occur within these stands, but are infrequent. White pine can persist in the spruce-fir climax but not as abundantly as on outwash plains.

The type, abundance, and diversity of ground vegetation varies with topography. Aster, wintergreen, and blueberry are common on ridges. Aster, beaked hazel, serviceberry, red maple, and balsam fir are common on slopes, especially where the soil moisture regime is dry to fresh. There is a clear break in the productive potential between sites where the soil depth is less than 60 cm and where deeper soils occur. The potential for full stocking may be limited where very shallow till sites prevail, such as exposed bedrock.

Productivity for white pine and red pine approximates Plonski's (1981) site class 1 where deeper soils predominate, and site class 2 or 3 where shallow soils are prevalent.

Dumped Till over Moulded Till

Dumped till over moulded till sites are either flat or gently rolling and are generally more uniform than dumped till over bedrock sites. Usually, two layers of till are present over bedrock; a loose

till of variable depth (which serves as the rooting zone) over a compacted till. The soils associated with these sites are fresh to moderately moist, often with a relatively high silt and clay content. Organic matter accumulations are usually minimal on these sites. White pine grows in association with tolerant hardwoods, white spruce, and balsam fir, all of which provide considerable competition. Red pine is seldom a significant component on these sites because it cannot tolerate competition. White pine, white birch, and aspen usually become established as a result of heavy logging or wildfire. White pine may persist within the more tolerant climax communities common to this land type, but only as scattered remnants.

Ground vegetation is often more abundant and aggressive on this site type than on outwash plains or dumped till over bedrock site types. Aster and beaked hazel are common on the fresh to moist upper slopes, while bunchberry, maianthemum, seedlings of balsam fir, and tolerant hardwoods are common on lower slopes.

Productivity approximates Plonski's (1981) site class 1 or 2 for white pine and site class 2 or 3 for red pine.

Lacustrine Deposits

This landform is less common than those previously described. These generally flat areas are comprised of fine textured soils, including silt loams, clay loams, and clays. The soil moisture regime varies from fresh to moderately moist, depending on local site conditions. The summer microclimate is best described as warm and dry.

White pine grows in association with tolerant hardwoods, but red pine is an insignificant component on these sites because it cannot tolerate the intense competition provided by the more tolerant species that are prevalent on these nutrient-rich sites. Plantations of both species have been established on this site type in southern Ontario.

Ground vegetation on lacustrine deposits is very similar to that found on dumped till over moulded till sites. In southern Ontario, perennial grasses dominate previously cultivated sites. Site productivity depends on the prevailing soil texture, with silt loams approximating Plonski's (1981) site class 1 for white pine and red pine. Productivity of clays and clay loams approximates site class 2 for white pine and site class 3 for red pine.

2.3 Silvics of White Pine and Red Pine

The silvical characteristics of white pine and red pine are discussed in this section of the guide. The information presented here, together with that provided in section 2.2, "Site," provides the foundation for the development of silvicultural ground rules for the white pine and red pine working groups.

2.3.1 Reproduction

White pine and red pine are monoecious. Female flowers develop near the apices of vigourous twigs in the upper portion of the crown; male flowers are borne in groups around the base of branches in the middle to lower crown (Wright 1953, 1970; Hard 1964; Fowler and Lester 1970). Flower initials of both pines are formed in the year preceding flowering (Horton and Bedell 1960). In the first few years of flower production, white pine produces predominantly female flowers (Wright 1970).

In Ontario, the male flowers of both species usually become visible in late May, and the female flowers appear about two weeks later. White pine flowers of both sexes are yellow-brown in colour, while those of red pine are purple. Pollination takes place in early to mid-June for red pine and about two weeks later for white pine (Horton and Bedell 1960).

White pine pollen production declines in stands greater than 150 years of age; red pine pollen production may also decline (Wright 1953). Both pines can self-pollinate, but the progeny is inferior to that resulting from cross-pollination (Johnson 1945). It has been estimated that pollen will only disseminate effectively for 30 to 60 m (Young and Eyre 1937).

After pollination, the female flowers for both species develop into small, green conelets. By the end of the first growing season, the white pine conelet is elongated and about two centimetres long; the red pine conelet is round and approximately two centimetres in diameter. Fertilization takes place about mid-July of the following year (Horton and Bedell 1960). Depending on weather conditions, the cones of white pine ripen from mid-August to early October and those of red pine from mid-September to late October (OMNR 1986c). During ripening, white pine cones turn from yellowish green to brown, and red pine cones change from green to purple, then to brown (Horton and Bedell 1960).

White pine begins bearing seed at about 15 years of age. Red pine seed bearing starts later, at approximately 25 years of age. Optimum seed-bearing age for both species occurs between 50 and 150 years (OMNR 1977).

Good crops of white pine seed can be expected at three-year to five-year intervals, with light crops in most intervening years (Fowells 1965). The frequency of good seed years declines in overmature white pine stands, being seven to eight years in 180-year-old stands in the Temagami area.[6] In addition, the amount and viability of seed per hectolitre is less in these old stands.

Good crops of red pine seed are infrequent and irregular, occurring every three to seven years, with bumper crops every ten to twelve years (Fowells 1965). The infrequency of good seed years is a major factor limiting regeneration of this species by natural seeding. Red pine may not

[6] Honeyborne, D., Forester, Central Ontario Forest Technology Development Unit, OMNR, North Bay, Ontario, Personal Communication.

produce any seed at the northern limits of its commercial range, except where the climate is moderated.[7]

The cone yields associated with good seed years are estimated to be 1.8 hl per tree for white pine and 0.5 hl per tree for red pine (OMNR 1977). These yields represent, on average, approximately 65 000 viable seeds per tree for white pine and 45 000 viable seeds per tree for red pine (OMNR 1986c). Average germinative energy is about 77 per cent for white pine and 92 per cent for red pine (OMNR 1977). Most seed is dispersed within one month after cone maturity, although some red pine seed dispersal continues until the following spring, especially if weather conditions are wet and cool in the fall (OMNR 1986c). The seed of both species may travel up to 80 m within the stand and 200 m in the open. However, most seed falls within a radius comparable to the height of the tree.

Open-grown trees of both species develop large crowns and hence yield more cones per tree (Godman 1962; Roe 1964; Sims and Campbell 1970; Stiell 1978). Dense stands of short-crowned trees in the intermediate or suppressed crown classes are poor cone producers (Fraser 1951; Graber 1970). Cold, wet weather during flowering or pollen shed may greatly reduce seed set (Stiell 1978). Poor weather and cone insects can greatly reduce the seed crop locally or regionally. Cone insects especially can cause very significant reductions in the size of the cone crop. Lyons (1960) indicated that the cone crop of open-grown red pine attacked by cone insects may be reduced by 40 to 100 per cent. Prior to germination, shed seeds may be eaten by a variety of mammals (such as squirrels and chipmunks) and birds (such as grosbeaks and bluejays). These factors should be considered when evaluating cone crops. Crop forecasting techniques and cone collection procedures are outlined in *Guidelines for Tree Seed Crop Forecasting and Collecting* (OMNR 1986c).

White pine and red pine do not reproduce vegetatively in nature. Both species can be reproduced artificially through grafting and cuttings, but red pine is less receptive to this technique (Horton and Bedell 1960; Fowler and Lester 1970; Wright 1970).

2.3.2 Establishment

Normally, white pine and red pine will germinate in the spring or early summer when temperature, moisture, and aeration levels of the seedbed are favourable. White pine seed exhibits embryo dormancy, which is broken by natural stratification in the autumn and early spring (Horton and Bedell 1960). Favourable seedbeds include moist mineral soil, polytrichum moss, and short grass of light to medium density (Toumey and Neethling 1924; Smith 1951). Less desirably, white pine will germinate on recently burned seedbeds or on heavy litter under the canopy of a mature forest (Ahlgren 1976). Best germination conditions consist of partial shade, light vegetation, and litter with some mineral soil exposure (Smith 1951; Heckman et al. 1985).

[7] Heikurinen, J., Consultant (formerly Regional Forestry Specialist, Northeastern Region, OMNR) Sudbury, Ontario, Personal Communication.

Red pine does not exhibit seed dormancy and has more exacting seedbed requirements than white pine has. The seedlings only survive in partially shaded places where mineral soil is exposed or where grass and litter are not thick (Rudolf 1957). High temperatures that occur on fire-blackened soil surfaces for the first few years after fire are lethal to small red pine seedlings (Ahlgren 1976).

White pine is classified as intermediate in shade tolerance. Seedlings of this species can achieve maximum height growth in 50 per cent full sunlight. Height growth is possible in 25 per cent full sunlight but at a reduced rate (Logan 1950, 1951, 1959; Lancaster and Leak 1978). However, leader diameter and biomass increase significantly with exposure to full sunlight.

Red pine is classed as intolerant to shade. Seedlings of this species exhibit good height growth for the first five years in 45 per cent light but require full sunlight for optimum growth (Logan 1966). Seedlings that germinate under dense shade rarely persist for more than 10 years.

A dense layer of grass, shrubs, herbs, or tolerant hardwoods suppresses and greatly weakens white pine and red pine seedlings (Smith 1951; Heckman et al. 1985). Red pine is particularly sensitive to competition. White pine is more competitive because root penetration occurs more rapidly. Consequently, white pine seedlings are able to take advantage of soil moisture below the general rooting zone of competing vegetation (Shirley 1943). Compacted snow may smother small seedlings of either pine.

White pine and red pine seedlings exhibit very slow height growth during the first five years. After this period, an annual height increment of 30 cm or more is often achieved in the absence of competing vegetation (Harlow and Harrar 1941; Lancaster 1984). It usually takes eight years or more for natural regeneration of white pine to reach a total height greater than one metre. Natural regeneration of red pine may achieve this level of growth in five years where vegetative competition is not limiting. In contrast, their hardwood competitors are very fast growers, with white birch achieving one metre or more in three years and aspen suckers in full sunlight reaching one metre in one year.[8]

2.3.3 Development

Stem and Crown

White pine and red pine usually produce one flush of height growth each year. One annual whorl of lateral branches is formed at the end of the leading shoots. Occasionally, a second flush produces lammas shoots in late summer. Lammas growth is probably the result of late summer rains following a dry spell.

For both pines, the length of the terminal shoot is determined by the number of needle internodes laid down in the previous year's bud. However, moisture stress and the effects of competing

[8]OMNR, Forest Resources Branch Policy No. FR 14 02 01 PO (1988), *Regional Free-to-grow Standards*.

vegetation can limit elongation of the internodes. Stem elongation usually begins in May and extends over a period of six to eighteen weeks, with most growth occurring within the first few weeks.

Height growth of white pine and red pine begins slowly, increases rapidly to a maximum, then tapers off in decadence (Horton and Bedell 1960). For white pine, annual height increment in open-grown plantations tends to peak just prior to crown closure, and then stabilizes at relatively high levels for long periods of time (Chapeskie 1983).

When the terminal leader of white pine is damaged by the white pine weevil, a leader shift to the strongest lateral usually occurs. This lateral is thin-stemmed, pliable, and at an acute angle to the vertical stem. A main stem with a short crook results (Lancaster 1984).

Vigourous trees are characterized by symmetrical crowns, while trees of low vigour develop flat-topped crowns. Both species exhibit vertical differentiation of the crown canopy into dominant, co-dominant, intermediate, and suppressed classes. White pine is able to grow well at higher densities than red pine and is less susceptible to stagnation, because it possesses a strong vertical tendency to differentiate its canopy and it has a higher degree of shade tolerance. Red pine grows tall and spindly at high densities and becomes subject to ice and wind damage (OMNR 1986d).

Stand density is critical to controlling the length and thickness of branches and the amount of foliage they bear (Stiell 1978). Both white pine and red pine develop broad, coarse-branched crowns when grown in low-density stands. More food reserves are directed to the production of lateral branches, where there is no side or overhead shade. When grown in dense conditions, both species display a degree of self-pruning as a result of lateral abrasion and mutual shading, especially in mixedwood stands. Red pine is a better self-pruner than white pine. White pine tends to retain dead branches for long periods of time, especially where the prevailing microclimate is dry (Richards et al. 1962).

The bark of young trees of both species, but especially of white pine, is thin and easily damaged by fire and sunscald. Mature bark becomes furrowed and thick, which increases its resistance to fire (Stiell 1978).

Roots

Both white pine and red pine have extensive, deep root systems that can penetrate to a depth of three to four metres. In early years, both species usually develop a taproot with numerous branched laterals. The taproot is less often retained in white pine. Lateral roots generally remain within 10 to 20 cm of the surface (Brown and Lacate 1961). These roots are long and wide-spreading, with large areas being shared by the root systems of many trees and not just those of immediate neighbours (Stiell 1978). Lateral roots may be damaged by hot surface fires even though the outer bark on the trunk is only lightly scorched.[9]

[9] Honeyborne, D., Forester, Central Ontario Forest Technology Development Unit, OMNR, North Bay, Ontario, Personal Communication.

The extent and character of white pine and red pine root systems is influenced by the physical and chemical properties of the soil. The roots of white pine will spread out over the surface of an obstruction when penetration becomes difficult. Red pine is unable to accommodate obstructions in this manner because of its geotropic rooting tendencies. Both white pine and red pine develop masses of fine roots in fine textured bands of soil with a fresh moisture regime (Brown and Lacate 1961). White pine develops shallow, flattened root systems where the water table is high or where the depth to bedrock is shallow. The downward growth of red pine roots is restricted in moist soils because of inadequate soil aeration (Fayle 1975).

White pine and red pine will develop natural grafts with root systems of neighbouring trees of the same species (Stiell 1978). Root grafting may delay tree mortality in suppressed crown classes (Bormann 1966) and may be a mode of transmission for root rot diseases (Gross 1970).

2.3.4 Growth and Yield

Both white pine and red pine have a very high growth and yield potential on sites to which they are biologically well suited. White pine has demonstrated the capacity to sustain high levels of volume production on relatively long rotations (Ardenne 1950; Barrett et al. 1976; Plonski 1981; Cooke and Barrett 1985). Red pine is also a high-volume producer but its capacity to sustain high growth rates is less (Plonski 1981).

Height and Diameter Growth

In natural stands, whether pure or mixtures of the two species, red pine initially outgrows white pine in height. White pine overtakes red pine at a breast-height age of 70 years on the most productive sites and 85 years on the poorest sites (Plonski 1981).

In mixed plantations of the two species, development patterns are affected by initial spacing and site factors. Where plantations are established at normal spacing on dry sites, white pine often lags behind and is suppressed by red pine. This effect is intensified when white pine loses height growth as a result of attacks by the white pine weevil. White pine will be favoured where plantations are established at wider spacings on more productive, fresh sites.

Stand density has little or no effect on height growth of either species (Smithers 1954). However, diameter growth is strongly related to the density of dominant and co-dominant stems. Over a range of densities, properly timed thinnings in the main canopy accelerate diameter growth of individual stems (Beckwith and McNeice 1978; Benzie 1977; Chapeskie 1983; Leak 1985; Gillespie and Hocker 1986a,b).

Natural stands of white pine may achieve mean diameters up to 90 cm when mature, although smaller average diameters are more usual. Natural stands of red pine achieve mean diameters of 30 to 60 cm over the life of the stand depending on stand density (Stiell 1978). Data presented

by Horton and Bedell (1960) for natural stands show that the mean diameter of the 125 largest white pine and red pine trees per hectare ranged from 46 to 53 cm over 290 plots in 3 different site groupings.

The potential for height and diameter growth is greatest for dominant and co-dominant trees. Intermediate and suppressed trees show a limited response to thinning or overhead release. Without treatment, many of these trees die (Cooke and Barrett 1985; OMNR 1986d).

The height growth of both white pine and red pine is strongly related to site quality (Horton and Bedell 1960; Plonski 1981). When grown in natural stands, white pine may achieve a mean height of 20 m on sites of low productivity and 34 m on sites of high productivity. Similarily, red pine may achieve heights of 17 m and 27 m, respectively (Plonski 1981).

An overstory may restrict the height growth of both white pine and red pine. White pine is more tolerant of reduced light levels and increased competition for physical space than red pine is (Stiell 1978). It can respond to release after many years of light to moderate suppression. However, if heavily suppressed by shrubs such as raspberry or beaked hazel, young trees die within a few years. Red pine cannot tolerate severe suppression for an extended period of time (USDA 1983). Height growth of red pine can be greatly reduced by competing vegetation, such as herbs and poplar suckers (Stiell 1978; Stone 1980), or a hardwood overstory (Stone and Chase 1962; Benzie 1977).

Satisfactory development of young white pine seedlings and planted stock can be expected under aspen suckers on drier sites because aspen rapidly loses vigour and self-thins. Some leader damage from whipping can be expected as the pines develop on these sites. On fresh sites, neither white pine nor red pine can compete with aspen sucker growth.

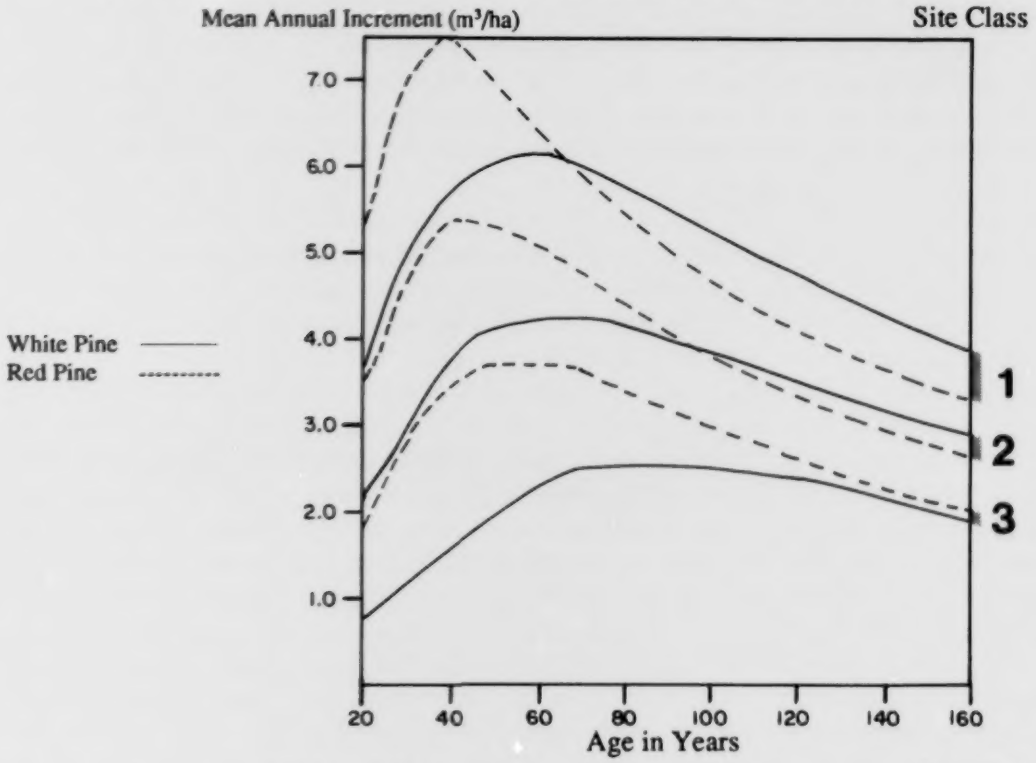
Stand Volume Increment and Yield

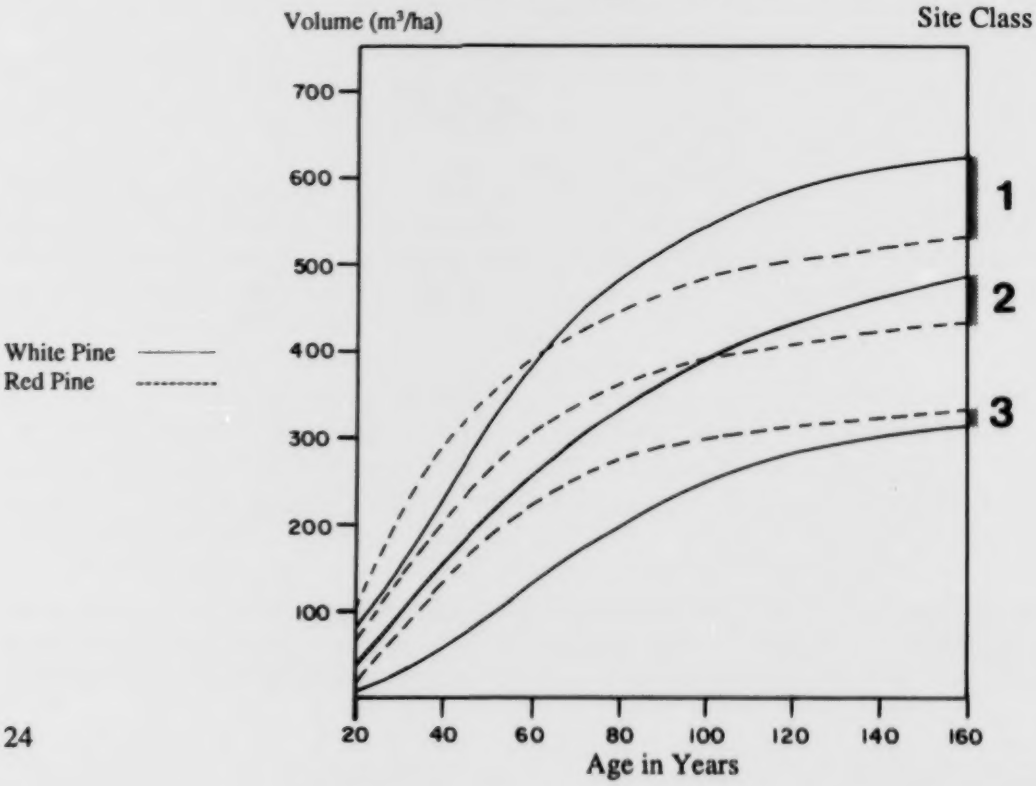
Stand volume increment and yield are strongly correlated with site quality for both species. The yield potential of red pine is higher than that of white pine to about age 60 years on highly productive sites and beyond this age on sites of lower productivity. White pine surpasses red pine in volume at 60 and 100 years of age on site class 1 and site class 2, respectively (Plonski 1981). This information is presented graphically in Figure 6.

For white pine, yield potential from age 100 years is about two times greater on site class 1 than on site class 3 (Figure 6); in comparison, red pine yield potential from age 80 years is one-and-one-half times greater on site class 1 than on site class 3 (Plonski 1981). In natural stands, white pine has attained merchantable volumes of 594 m^3/ha by 190 years and red pine 470 m^3/ha by 160 years (Stiell 1978).

On site class 1, mean annual increment of gross total volume culminates at 55 years for white pine and 40 years for red pine. Volume production for white pine varies from 1 to 6 m^3/ha/a depending on site quality and age; volume production for red pine ranges from 2 to 7 m^3/ha/a

Figure 6: Gross total yield and mean annual increment by age and site class for natural stands of white pine and red pine in Ontario (adapted from Plonski [1981])





(Figure 6). On very productive sites in southern Ontario, growth rates of over 12 m^3/ha/a have been recorded for red pine (OMNR 1986d).

Many yield tables applicable to white pine and red pine management in Ontario are available. A brief description of these tables and the study area for which they were developed are contained in Table 2. The information provided in these tables may be useful for economic analysis. Plonski's (1981) yield tables should be used as a provincial standard when comparing regional yields.

Rotation Length

Rotation ages will vary greatly depending on the site quality, initial spacing, desired size specifications, and intensity of management. Trees larger than 30 cm are currently most in demand.

At present, rotations of 80 to 150 years are commonly prescribed across the commercial ranges of white pine and red pine. Smithers (1954) recommends rotations of 100 years for thinned and 120 years for unthinned white pine and red pine stands when minimum crop tree DBH was set at 30 cm. McCormack (1956) suggests rotations of 30 to 65 years for pole wood products on his site classes I to IV, respectively, and 80 to 130 years for sawlog products. Ardenne (1950) gives rotation age ranges (based on maximum growth rate) of 130 to 150 years for white pine and 100 to 110 years for red pine.

Rotation lengths of 40 to 80 years may be possible in the future depending on the site quality, intensity of management, and prevailing product specifications (Schreiner 1970). Preliminary studies of white pine indicate that while marketable stands may be produced sooner on shortened rotations, cumulative yields per rotation may be reduced, particularly when a low-density management strategy is applied at an early age (Leak 1985).

Preliminary economic studies indicate that, for white pine, there is a relatively broad range of rotation ages over which financial returns will not vary greatly (Irland 1985). This pattern reflects a steady level of increased value with age, based on current product specifications. Hibbs and Bentley (1987) present the results of a simulation of volume-versus-value growth for white pine. They state, "Final rotation length is a balance between decreasing rates of volume and value growth and the opportunity cost of carrying the continually increasing volume or capital."

Rotation ages have been calculated for fully stocked natural stands in Site Regions 4200 and 5200 in the Northeastern Region. A summary of this information is provided in Appendix IV. Mean annual increment by gross total volume and net merchantable volume, equivalent annuities, and product categories are projected in the tables from which this information is derived.[10]

[10]Some of this information can be found in Kershaw, H.M. (Compiler). 1988. Forest site evaluation field manual. Volume 1. OMNR, Northeastern Region, Sudbury, Ontario.

TABLE 2: Growth and Yield Information Applicable to White Pine and Red Pine Management in Ontario

Species	Study Area	Characteristics	Source
White pine and red pine	Ontario	Yield tables (total and merchantable volume) Age range: 20 to 190 years for white pine and 20 to 160 years for red pine Natural, fully stocked, unmanaged stands Three site classes	Plonski (1981)
White pine and red pine	Northeastern Region	Yield tables (total and merchantable volume) By site region for specific soil types	OMNR (1983)
White pine, red pine, or combinations of the two	Algonquin Region	Yield tables (total volume) for ages 20 to 200 years Average stands Four physiographic site-types	McCormack (1956)
White pine, red pine, or combinations of the two	Algonquin Region	Yield tables (total volume) Age range: 10 to 100 years for unmanaged stands and 30 to 100 years for regularily thinned stands Fully stocked stands, unmanaged and managed Five site-index classes	Smithers (1954)
Red pine	Algonquin Region	Variable-density yield tables Unmanaged plantations	Berry (1977)
Red pine	Algonquin Region	Yield tables (total volume) to age 70 years Thinned plantations Three productivity classes	Love and Williams (1968)
Red pine	Central Region	Variable-density yield tables Managed plantations Range of sites	Beckwith et al. (1983)
White pine	Eastern and Central Regions	Volume and stocking tables only Extensively managed, open-grown plantations	Chapeskie (1983)
White pine and red pine	Southern Quebec	Variable-density yield tables to age 40 years for white pine and age 45 years for red pine Unmanaged, open-grown plantations Yield data from Chapeskie (1983) may be used to calibrate these tables to southeastern Ontario	Bolghari and Bertrand (1984)

2.3.5 Genetics

WHITE PINE

White pine exhibits considerable stand-to-stand variation (Genys 1968, 1978). Height growth, diameter growth, stratification requirements for seed, and response to daytime and night-time temperatures have been shown to be related to the geographic origin of the seed (Wright 1970).

Genetic research in white pine has focussed on species hybridization, provenance studies, vegetative propagation, and plus-tree progeny studies (Wright 1970; Garrett 1985; Zsuffa 1985a,b). Research activities in Ontario and the eastern United States have demonstrated that there is potential to improve both qualitative and quantitative aspects of white pine (Zsuffa 1985a,b). The quality of white pine can be significantly improved by selecting for desirable stem and branch form and for improvements in the morphological characteristics of the wood (Wright 1970; Zsuffa 1985a,b). White pine yields can be improved by selecting for superior height and diameter growth. In addition, it is possible to develop strains of white pine that are less susceptible to the damaging impact of white pine blister rust, white pine weevil, and environmental pollutants (Garrett 1985; Zsuffa 1985a,b). However, the genetic control of these factors is very complex, which greatly lengthens the selection process.

A hybrid of eastern white pine and Himalayan pine that exhibits moderate resistance to blister rust has been developed. A seed production orchard containing this hybrid is located at Orono nursery and seed may be requisitioned for nursery stock production. This stock should be utilized in areas of moderate rust hazard. Genetically improved nursery stock should be placed on the best sites available and should be well maintained so that the benefits of tree improvement efforts are realized.[11]

The availability of improved stock can have a significant influence on silvicultural practices. For example, deployment of blister rust-resistant nursery stock in areas of moderate risk would make control measures, such as low pruning, less important. The use of fast-growing strains could result in shortened rotations.

The use of tree marking to control the residual seed source is very important where the uniform shelterwood and clear cut with seed trees systems are used. Trees with desirable phenotypic characteristics (e.g., fine branching and straight stem) should be retained to supply seed. Thinning have been shown to improve weevil resistance of the progeny from the remaining crop tree parents (Ledig and Smith 1981). Seed used in the artificial regeneration program should be obtained from controlled collection areas (e.g., seed collection and seed production areas).

Additional information can be obtained from *Tree Improvement Master Plan for Ontario* (OMNR 1987f) and from regional tree improvement strategy documents.

[11]Rauter, R.M., Manager, Ontario Forest Industries Association (formerly Supervisor, Tree Seed and Forest Genetics Unit, Forest Resources Branch, OMNR), Toronto, Ontario, Personal Communication.

TABLE 3: The Occurrence, Biology, and Management of the Important Damaging Agents of White Pine and Red Pine in Ontario

Insects	High-Risk Sites	Affected Species	Biology, Signs, and Symptoms	Range	Management Implications
White pine weevil	Unshaded conditions with low relative humidity and high air temperature. Dry sites, which are ideal for overwintering of the adults; open-stand conditions can prevail longer here than on fresh sites. Sites within 5 km of established white pine stands are at greatest risk. Sites 10 to 20 km downwind from established white pine stands are also at risk.	White pine trees between 2 to 6 m in height are most susceptible. Jackpine and Norway spruce.	Behaviour and development of the insect is largely influenced by microclimate, including bark temperature, solar radiation, and atmospheric moisture. Insects prefer a thick stem leader, rejecting leaders less than 4 mm in diameter. Adults reside in litter close to the bole, emerging over several weeks in early spring. Adult weevils are poor flyers; they have difficulty reaching heights in excess of 6 m. Feeding and oviposition are rapid and are largely confined to the bark of preceding year's growth; the leader is effectively girdled. Leader withers, assuming characteristics of a shepherd's crook. Adults emerge from the stem in summer or early fall, seeking hibernation sites.	Throughout the commercial range.	Without management, there is potential for reduction in stem quality and value by 20 to 60 per cent (less for short logs) based on current utilization standards. Besides stem deformations, stem stubs resulting from insect damage are primary infection courts for decay fungi. Weevil-caused deviations from the vertical of 5 cm or less are of little consequence.
Redheaded pine sawfly	Shallow or disturbed soil, open stands, adjacent to a hardwood edge. Stands less than 5 m tall.	Red pine and, to a lesser extent, white pine.	Larvae feed in gregarious colonies and are active from mid-summer to fall, depending on weather conditions. In heavy infestations, preference is shown for the previous year's needles.	Infestations largely confined to an area south of the Mattawa-French line in northern Ontario.	Can cause growth losses or mortality in young stands.
European pine sawfly	Same as redheaded pine sawfly.	Red pine and, to a lesser extent, white pine.	Larvae are gregarious. Insects are active in the spring with timing dependant on weather conditions. Larvae feed only on the foliage of the previous year's shoots.	Southern Ontario.	Can cause growth losses or mortality in young stands.
Diseases					
White pine blister rust	Topographic conditions favourable to dew formation: valleys, lower slopes, and north-facing slopes.	White pine	Fungus enters through the needles and attacks the living bark and cambium, first breaking out in blisters and later forming pustules. Spores transmit the disease to gooseberry or currant plants. Spores from these hosts in turn infect healthy trees.	Refer to the Canadian Forestry Service hazard zone map (Gross 1985a).	Can cause heavy mortality and loss of tree vigour in young, developing stands.
Scleroderris canker (North American strain)	Trees in depressions and frost pockets, where a cool, moist microclimate may develop, are most susceptible. Where the fungus becomes established, development and spread of the disease is facilitated.	Red pine and occasionally white pine. Affects smaller trees.	Fungus produces two types of spores, with spore production and colonization of host tissue occurring when the weather is cool and moist. Conidia, often spread by rain splash, are considered the main source for local intensification of the disease. Ascospores have a role in local spread and are the main inoculum type for long range movement. Spread within the host occurs mostly during fall and winter. An orange discolouration appears at the base of new needles, most often in early summer. Needles turn brown and fall off the branch, leaving a bare dead shoot. An abundance of dead shoots provides cause to suspect damage is the result of scleroderris infection. Cankers may develop on branches or the stem with the potential to girdle and kill the tree. Green to yellow-green stain may appear underneath the bark in infected regions.	Throughout the commercial range with the exception of the eastern and south-western areas.	Can cause mortality of the current year's shoot and loss of tree vigour in stands where the trees are less than 2 m in height. Occasionally causes tree mortality in very young stands.
Scleroderris canker (European strain)	Refer to North American strain.	Red pine and occasionally white pine. All tree sizes affected.	Has the same signs and symptoms as the North American strain, but is more aggressive, infecting trees of all sizes. Infection usually starts in upper crown.	Several infection sites discovered in OMNR Districts of Bancroft, Bracebridge, and Parry Sound. Potential to develop anywhere across the commercial range.	Shoot infection often kills several growth nodes of a branch. Can damage or kill trees of any size.

Table 3 (cont.)

Diseases	High-Risk Sites	Affected Species	Biology, Signs, and Symptoms	Range	Management Implications
Fomes root rot	All sites.	Red pine and white pine. Potential for development in recently thinned stands.	Spores germinate on fresh cut stumps in thinned stands and colonize the stump and root issues. The pathogen spreads out from single tree infection centres through root grafts, causing gradual decline and mortality of trees. When root systems have partially decayed, a fruiting body is produced at, or slightly below, the ground line at the base of the tree. Fresh cut stumps are susceptible to invasion for 10-14 days.	Confined to southern Ontario. Insignificant in northern Ontario and in the northern part of Algonquin Region.	Potential for vigour loss and mortality in infected stands.
Red ring rot	Shallow soils with restricted rooting.	White pine, and to a lesser extent, red pine. Decay is prevalent in the butt region of the tree. Decay is very significant in overmature stands.	Pathogen enters the trunk through external wounds (e.g., logging scars, root injuries, or weevil-affected branch stubs). Fungus causes distinctive white pocket rot, the pockets being surrounded by relatively firm wood tissue.	Throughout the commercial range.	Will affect the optimum rotation age. Can cause very significant growth and value losses, especially in overmature stands.
Mammals					
Deer	Where alternate preferred browse is scarce. Deer yarding areas.	Both pines, but especially, white pine. Small seedlings. Occasionally, lower branches on taller trees.	Terminal shoots and branches are consumed, causing forking of stem, growth loss, and seedling mortality.	Throughout the commercial range.	Could be a concern in areas of high deer densities where other preferred browse within reach of the animals is lacking. Could be a concern in some shelterwood cuts if sufficient browse is unavailable.
Mice	Damage potential is highest where soils are nutrient rich, with a fresh to moist moisture regime. Grass and herb vegetation provide cover and security for this rodent.	Both pines. Affected trees are less than 1m tall.	Bark is gnawed off at the base of the tree; girdling may result, with needles turning brown. Populations are cyclical.	Throughout the commercial range.	Mice can cause extensive damage and mortality where competing deciduous vegetation is abundant.
Rabbits and hares	Damage is greatest in clearcuts, because of the potential for the development of good habitat (e.g., slash piles, dense hardwoods, and shrubs). Open fields where there is dense cover (e.g., hardwoods or shrubs in adjoining areas).	Both pines, especially white pine. Damage usually confined to trees less than 1 m tall. Norway spruce and jack pine preferred over white pine and red pine.	Affect terminal shoots and branches, causing forking of stem, growth loss, and seedling mortality.	Throughout the commercial range.	Can cause extensive clipping and deformation of young developing pine.
Porcupines	Stands in proximity to Scots pine plantations.	Red pine, Scots pine, and, to a lesser extent, white pine.	Girdle branches and kill tops of trees.	Throughout the commercial range.	Can seriously affect the quality of individual trees.

Red pine is a much more genetically uniform species than white pine is (Fowler and Morris 1977), although variation in a number of characteristics, including growth rates, wood quality, and photoperiod, has been documented. However, the pattern is often obscure and difficult to relate to climatic data for the species (Fowler and Lester 1970). The 10-year results of comprehensive provenance trials with red pine have shown differences in height growth at individual test sites throughout eastern and central Canada. The consistently poor performers were obvious, and some potentially good seed sources were identified (Holst 1975). The seed collection zone principle is, therefore, appropriate to this species.

Although red pine plays a significant role in Ontario's artificial regeneration program, there is no provincial tree improvement strategy for genetic improvement of this species. Genetic variation is too low to be of practical significance. However, the collection of seed from managed seed production areas is desirable for economic reasons.

2.3.6 Damaging Agents

It is beyond the scope of this guide to prepare a detailed summary of all the damaging agents affecting white pine and red pine. White pine weevil, white pine blister rust, and red ring rot can seriously damage white pine. Sawflies, scleroderris canker, and fomes root rot can seriously damage red pine. Deer, mice, rabbits, and porcupines can cause damage to either species locally. The occurrence, biology, and management implications of damaging agents of white pine and red pine in Ontario are summarized in Table 3.

Several damaging agents of white pine were described during a symposium on white pine held at the Petawawa National Forestry Institute in 1984 (refer to de Groot [1985]; Gross [1985a,b]; Syme [1985]; Wallace and Sullivan [1985]). Excellent references dealing with the damaging agents of red pine include *Managing Red Pine Plantations* (OMNR 1986d) and *Managing Red Pine* (SAF 1985). A publication describing the North American and European strains of scleroderris canker (Dorworth and Gross 1979) and a pictorial guide to assist with its recognition (OMNR 1988b) are also available. Detailed guidelines on the biology and control of the white pine weevil and white pine blister rust are being prepared by OMNR for publication in the near future.[12]

2.4 Wildlife Considerations

Wildlife management should be considered to be an integral part of timber management. The basic requirements of wildlife include food, water, and shelter from weather and predators. Planning for diversity in vegetation communities and recognizing the specific habitat requirements of various wildlife species is the key to effective wildlife management. The management of timber for moose or deer habitat will produce vegetative patterns that benefit many other

[12]Juzwik, Dr. J., Provincial Pathologist, Pest Management Section, Forest Resources Group, OMNR, Sault Ste. Marie, Ontario, Personal Communication.

species. Some species may require special habitat management to meet their needs. Silvicultural activities, including harvest, can be very beneficial to a wide range of wildlife species, provided that timing, location, and intensity of treatment are considered in relation to the biological requirements of the species. General habitat requirements for important wildlife species and wildlife management objectives are summarized in Table 4. More information can be obtained by consulting guidelines and resource manuals prepared by OMNR Wildlife Branch.

The white pine and red pine working groups are very important to wildlife. Since both pure and mixedwood stands will be favoured in pine management, depending on the site, a key element of diversity will be provided across the commercial range of the working groups. In planning for wildlife, the nature and stage of the development of all working groups, including pine, must be considered. The spatial and temporal requirements of wildlife must be balanced against the requirements for effective pine silviculture. In this way, resource conflicts can be minimized and requirements for effective wildlife and timber management can be met.

2.4.1 Large Mammals

There is extensive literature on the ecology of Ontario's principle wild ungulates: moose and deer. OMNR's Wildlife Branch has developed guidelines for the habitat management of both species, and these should be referred to during management planning. There has been less research on the ecology of black bear, although there have been major studies in Ontario and Minnesota. White pine and red pine growing in pure or mixedwood stands contribute greatly to the habitat requirements of all three species.

White-tailed Deer

White-tailed deer make extensive use of white pine, hemlock, cedar, and hemlock-pine-spruce-balsam associations for winter shelter. Red pine is a marginally important conifer component because of its relatively sparse crown. Red oak, a common associate of white pine, provides an important food source through mast production.

Forestry practices in conifer associations are a key element in deer management because deep snow and cold weather force deer to take shelter during winter. Conifer cover with at least 60 per cent canopy closure supports the snow load, promotes sublimation rather than deposition, and acts as a windbreak, thus reducing radiant heat losses. The principle objective of forest management within yarding areas is to provide a continuous supply and high degree of interspersion of browse adjacent to conifer cover. Deer tend to concentrate in traditional wintering areas, referred to as "yards"; they often use the same areas year after year. Because of this traditional use of yards, the elimination of units of winter habitat may cause local die-offs (Telfer 1978).

Management practices that protect or foster high-yield mast trees (oak, beech) should be considered on productive sites adjacent to winter habitat. Cutting in deer wintering areas should

Table 4: Wildlife Habitat, Timber Management Concerns, and Timber Management Strategies within the White Pine and Red Pine Working Groups*

Selected Species	Wildlife Habitat	Concern in Timber Management	Timber Management Strategies to Maintain/Enhance Habitat
Deer	Dense conifer as winter shelter Early successional vegetation for food Grassy, permanent openings for seasonal foraging requirements	Maintenance of current potential shelter (yards) Maintenance of early successional forest adjacent to winter shelter	Cut within winter yards to maintain or enhance shelter value Produce a mosaic of small cuts and leave blocks to benefit foraging deer and provide shelter
Moose	Pure conifer stands for late winter shelter; mature upland mixedwoods for food and shelter; early successional areas for food Wetlands, for aquatic feeding Mineral licks, calving sites	Maintenance of winter shelter and security cover Maintenance of aquatic feeding areas, mineral-lick sites, and calving sites Shelter from weather and predators	Use a relatively intense shelterwood cut to create a mosiac of sizes, with uncut buffers of intact conifer or mixedwood within cuts Leave lakeshore reserves
Black bear	Mixed habitat, including riparian forests; mature upland mixedwoods for den sites and feeding; early successional areas for feeding Stands of mast (oak, beech) for specific foraging requirements	Enhancement of food supplies by cutting (early successional forest) Maintenance of den sites. Maintenance of selected mast-producing oak and beech stands	Design cuts with a high edge-to-area ratio Open canopy to stimulate growth of herbaceous vegetation Protect known den sites Protect high-yield mast stands (e.g., oak, beech)
Ruffed grouse	Mixed forest with a relatively low conifer component and uneven-aged aspen throughout Small openings and riparian areas Mature hardwoods for nesting Aspen for winter feeding	Maintenance of diversity (e.g., conifer, mixedwood)	Create small openings Maintain units of conifer cover, but avoid extensive areas of this type. Maintain uneven-aged aspen in patches throughout each managed area
Passerine birds	A broad array of forest habitats	Maintenance of diversity Maintenance of sizeable areas of undisturbed habitat for climax-adapted species	Enhance diversity, but maintain some large stands
Raptors (other than eagles, ospreys)	A wide range of habitats Generally more closely associated with mature, undisturbed forest than with other groups	Maintenance of specific nesting sites Maintenance of areas of mature forest	Protect specific nestings sites Maintain refugia Protect riparian and lowland habitats

* Reference should be made to individual guidelines for further concerns, the context of these concerns, as well as explanations of the allowable refinements of the guidelines

Table 4 (cont.)

Selected Species	Wildlife Habitat	Concern in Timber Management	Timber Management Strategies to Maintain/Enhance Habitat
Osprey	Riparian areas, nest in dead or open-topped trees	Avoid loss of current and potential nest sites Avoid habitat disruption and loss near nest site Avoid disturbance during sensitive period: - Osprey - approximately April 15 - September 1 - Herons - approximately April 1 - August 15 - Bald and golden eagles - approximately February 15 - September 1 - Peregrine falcon - approximately March 15 - September 1	No timber management activities in immediate vicinity(^) of nest at any time Modified cutting is possible near nest(^) during non-sensitive periods
Herons	Riparian areas		
Bald eagle (endangered species)	Riparian areas; nest in very large trees		
Golden eagle (endangered species)	Forested areas with large openings (burns, bogs, etc.) Usually nest on cliff ledges, but may also nest in trees		
Peregrine falcon (endangered species)	Nest on cliff ledges, especially near water; prey on small birds		
Beaver, otter, mink	Riparian areas	Maintenance of cover (including snags, stumps, wood debris and deciduous and herbaceous vegetation) in riparian areas	Protect shoreline vegetation Do some cutting to shore to enhance beaver habitat where desirable
Lynx, fox	Early to mid-successional areas; mixedwood stands of various ages	Regeneration of deciduous and herbaceous vegetation in cutovers to improve small mammal populations	Produce a mosaic of cut and uncut stands to maximize edge-effect and provide a mix of cover and early successional feeding areas
Marten, fisher	Immature and mature coniferous and mixedwood stands Often den in cavities in large trees	Protection of the overstory, especially for fisher	Apply shelterwood or modified cutting in strategic areas Ideally, leave remnant basal area of at least 20 m^2/ha Retain snags and potential snags within cutovers as safety concerns allow
Snowshoe hare	Diverse mixedwood forest Patchy openings, a high edge-effect Scattered conifer cover	Maintenance of diversity (hare damage to pine regeneration must be considered)	Maintain diversity in overall forest area

(^) Refer to individual guidelines for quantification of the terms "immediate vicinity" and "near nest"; these distances vary with individual species

follow deer yard management principles described in the provincial guidelines for white-tailed deer (OMNR 1986b). For non-yarding areas, the silvicultural systems used for the renewal of the white pine and red pine working groups produce good deer habitat, provided that there is adequate browse available within the treated area or within adjoining areas.

There is growing awareness of the importance of quality summer range in the annual physiological cycle of deer (Moutz 1978). Maintaining approximately 10 per cent of the forest landscape in openings, preferably those supporting grasses and forbs, is very important. For further information, refer to *Guidelines for Providing White-tailed Deer Habitat in Timber Management* (OMNR 1986b).

Moose

Several critical components of moose habitat have been identified. These include early and late winter concentration areas, aquatic feeding areas, calving sites, mineral licks, and shelter from weather and predators. White pine, red pine, and their associates may contribute significantly to these components throughout the commercial range. Moose readily exploit forests having extensive areas in early successional stages provided there is an interspersion of suitable conifer cover (Peck et al. 1976). A residual basal area of 11 m^2/ha or greater, with at least one-third comprised of conifer, provides ideal shelter. Protection of conifer and maintenance of forest cover is considered necessary to ensure the continued use of aquatic feeding areas, calving areas, and mineral licks. For further information, refer to *Timber Management Guidelines for the Provision of Moose Habitat* (OMNR 1988d).

Black Bear

Bear require a diverse forest landscape that provides food, shelter, den sites, and escape cover (Kolenosky 1981). The provision of openings in early successional stages for foraging is particularly important (Jonkel and McT. Cowan 1971; Kolenosky 1981; Rogers 1987). The presence of mast is also a key factor in the ecology of black bear (Kolenosky 1981; Rogers 1987). Heavily utilized beech and oak trees should be protected. Large, hollow pine trees are often selected as den sites (Rogers 1987), and it is important to leave a few such trees throughout the bear's home range. Management practices that produce small forest openings or reduce density to no more than 800 trees per ha will benefit bear (Rogers 1987). The application of *Guidelines for Providing White-tailed Deer Habitat in Timber Management* (OMNR 1986b) will contribute to good bear habitat, provided that consideration is given to the provision of large trees and snags as den sites.

2.4.2 Birds

Avian communities usually benefit from forest disturbance. Normally, there is an increase in the diversity and abundance of birds after logging (Webb et al. 1977; Neimi and Hanowski 1984).[13] However, certain species adapted to late successional stages will be displaced in affected areas.

The size of stands of continuous undisturbed habitat required by species intolerant to disturbance is important. There is evidence that areas such as these must be larger than the territories of a few individuals, since unfavourable weather conditions can eradicate small, isolated bird populations (James 1984a).

Upland Birds

Ruffed grouse, spruce grouse, and woodcock are the principal upland birds sympatric with the range of white pine and red pine in Ontario. Of the three, ruffed grouse is by far the most important. Management of mixedwood forests can dramatically influence the quality of grouse habitat. Conifers, including pine, provide winter roosting and escape cover, and are an important component of ruffed grouse habitat (Johnsgard 1973). However, ideal grouse habitat has only a small conifer component and management to produce a pure conifer forest over large areas would be detrimental (Gullion 1972; Gullion and Alm 1983). Grouse prefer a diverse mixedwood condition, with small openings and uneven-aged aspen interspersed throughout. Ontario's guidelines for deer management, as applied to the white pine working group, should provide fair but not ideal ruffed grouse habitat. For more detail on habitat management for ruffed grouse, refer to Gullion (1972) and Gullion and Alm (1983).

Spruce grouse are closely associated with jack pine for food (Chriton 1963) and with jack pine and spruce for cover (Pietz and Tester 1985). There is no known association of spruce grouse with white pine, red pine, or a mixedwood condition.

Woodcock are adapted to the early successional stage of disturbed forests. Any harvest treatment of pine stands will improve woodcock habitat. Management techniques applicable to mixedwood forests have been developed (Sepik et al. 1981).

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[13]Refer also to "Impact on bird populations of harvesting the boreal mixedwood forest," a paper given by D.A. Welsh, Research Biologist, Canadian Wildlife Service, Ottawa at a forestry-wildlife workshop hosted by the Ontario Ministry of Natural Resources, Sault Ste. Marie, Ontario, 1980.

Passerines

Many passerines (perching birds) make use of white pine and red pine stands but very few species are dependant on white pine or red pine at any stage of their life cycle. Many species, including bluejays and crows, nest in pines. Four warblers, the yellow rumped, pine, black-throated green, and blackburnian, are associated with white pine. The latter two are intolerant of forest disturbance. Four finches, the red crossbill, purple finch, pine siskin, and evening grosbeak, also inhabit pine forests, but only the crossbill is largely dependant on white pine. The clay-coloured sparrow, a sparsely distributed species in Ontario, utilizes young pine. Pine management may enhance this species.

It is unlikely that timber management will seriously harm any passerine species associated with the white pine and red pine working groups. The creation of a diversity of stand types and ages is important. The application of the moose and deer guidelines will benefit passerine birds. For more information, refer to *Habitat Management Guidelines for Warblers of Ontario's Northern Coniferous Forests, Mixed Forests and Southern Hardwood Forests* (James 1984c); and *Habitat Management Guidelines for Cavity-nesting Birds in Ontario* (James 1984a).

Raptors

Several species of raptors (birds of prey) nest in white pine, but it is difficult to gauge the effects of pine management because of a lack of information. Large pines along shorelines provide important and possibly critical nesting sites for osprey and bald eagles. Goshawks, sharp-shinned hawks, Cooper's hawks, and red-tailed hawks often nest in large white pine, as do the merlin (an uncommon Ontario species) and the long-eared owl. Some raptors show fidelity to nest trees, but whether use of specific nest sites is imperative is unknown. The Cooper's hawk prefers mature white pine stands for nesting.

With the exceptions noted above, it is difficult to assess the impact of pine management on raptors. As a group, raptors need mature, undisturbed forests. Management favouring small openings is useful, but long rotation ages for the surrounding forest are necessary. Provision for riparian and lowland habitats is also important. For more information, refer to *Habitat Management Guidelines for Ontario's Forest Nesting Accipters, Buteos and Eagles* (James 1984b), *Bald Eagle Habitat Management Guidelines* (OMNR 1987a), *Golden Eagle Habitat Management Guidelines* (OMNR 1987c), *Peregrine Falcon Habitat Management Guidelines* (OMNR 1987d), and *Management Guidelines and Recommendations for Osprey in Ontario* (Penak 1983).

2.4.3 Furbearers

The principal terrestrial furbearer species of Ontario are lynx, marten, fisher, and red fox. Lynx achieve good densities locally in the Great Lakes-St. Lawrence forests north of North Bay, but are probably best adapted to the mixed boreal forest. The latter three species find suitable habitat

in white pine and red pine forests throughout central and northern Ontario. Low-intensity, modified logging may benefit these furbearers. However, even modified clear cutting may reduce marten and fisher populations, and extensive clear cutting may reduce the carrying capacity for lynx and red fox.

Fisher are opportunistic regarding habitat, but avoid open places with no overhead cover (Strickland et al. 1982). Marten will not tolerate extensive clear cutting but will make use of cutovers adjacent to uncut blocks (Steventon and Major 1982). They will inhabit areas that have been partially cut, provided the residual basal area is at least 20 m^2/ha (Soutiere 1978). It appears that only modified or shelterwood cuts are acceptable for the maintenance of marten and fisher populations.

Lynx use early to mid-successional habitats resulting from disturbance. They require a mixture of habitats to provide proximity to mature conifer and uneven-aged forest conditions (Parker et al. 1983).

Beaver are the most important aquatic furbearers in Ontario, and logging operations near shorelands can affect beaver habitat. Forest management operations adjacent to shorelands that encourage the growth of deciduous species will favour beaver. The integrity of shoreline vegetation should be maintained where the protection of water quality and fisheries habitat is required. For more information, refer to *Guidelines for Providing Furbearer Habitat in Timber Management* (OMNR 1986a) and to *Timber Management Guidelines for the Protection of Fish Habitat* (OMNR 1988c).

2.4.4 Fish

Timber operations affect fish habitat primarily when they occur adjacent to such aquatic environments as lakes and streams. A description of the potential effects of timber operations on fish habitat can be found in *Class Environmental Assessment for Timber Management on Crown Lands in Ontario* (OMNR 1987b). Reference should be made to *Timber Management Guidelines for the Protection of Fish Habitat* (OMNR 1988c) for details regarding management practices. Some considerations are briefly outlined below.

Lake shorelines and streamsides are considered to be areas of concern, and harvesting and other operations within these areas should be conducted in a manner to minimize erosion and other potential adverse effects.

Streamside vegetation should be maintained to provide cover and food for fish, and to protect aquatic invertebrates as a food source. Removal of shoreline or streamside vegetation can increase water temperatures and reduce oxygen levels, and may be detrimental to coldwater species such as brook trout. This species spawns in shallow seepage areas that may be scattered around the shorelines of lakes. Since these areas are not often evident, the entire shoreline of such lakes requires a high level of protection.

Road building should be planned to minimize the number of stream crossings. Stream crossings adjacent to critical fish habitats, such as spawning areas, should be avoided where possible. Crossings should not obstruct the migration of fish. Construction of forest access roads can provide public access to lakes and streams that were previously inaccessible by land.

Wastes, such as slash and other organic material, decompose slowly in water, resulting in potential biochemical oxygen demand and a possible reduction in dissolved oxygen levels. Spawning areas are particularly sensitive to deposits of slash. The felling of trees and the introduction of logging debris into the water should be avoided.

2.4.5 Others

Several studies have documented a variable response in the small mammal community to clear cutting (Kirkland 1977; Monthey and Soutiere 1985). However, there is very little knowledge of the effects of pine management on small mammals.

It is known that the abundance and density of herb and shrub vegetation increase with treatment and provide food and shelter for these mammals. Management prescriptions in pine that open the canopy or produce a patchy forest should increase the overall abundance of small mammals, resulting in an enhancement of the entire community of predators and prey.

2.5 Environmental Considerations

Class Environmental Assessment for Timber Management on Crown Lands in Ontario (OMNR 1987b) states:

> Timber management operations can cause a variety of environmental effects. These effects can be positive or negative, short-term or long-term, direct or indirect, temporary or permanent, reversible or irreversible, or cumulative. The potential occurrence of any of the effects, their magnitude, and perhaps most importantly, the significance of the predicted effects, will vary between and within individual management units. Most negative environmental effects can be prevented or minimized through proper planning and implementation of timber management operations, or mitigated through application of effective remedial measures.

In Ontario, all potential provincial environmental effects are discussed in the above document. Local effects are dealt with during the development of the timber management plan. Normal operational procedures, as outlined in this guide, will usually be adequate to protect environmental values in areas where the white pine and red pine working groups are being managed. Environmental considerations for the timber management activities of road construction, timber harvest, renewal, and maintenance that are applicable to the white pine and red pine working groups are discussed below.

Road Construction

Forest access roads are a potential cause of soil erosion and the subsequent sedimentation of adjacent lakes and streams. Stream crossings pose the highest risk of sedimentation. Winter roads are preferable in areas that are highly susceptible to erosion. The problems and remedial measures are well described in *Design Guidelines for Forest Management* (Hough, Stansbury and Assoc. 1973). Considerations for the construction of forest access roads that minimize potential environmental effects are presented in *Environmental Guidelines for Access Roads and Water Crossings* (OMNR 1988a).

Timber Harvest

The shelterwood and clear cut systems are recommended for the harvest of white pine and the clear cut system is recommended for the harvest of red pine (section 3.1, "Silvicultural Systems"). Application of the uniform and strip shelterwood systems as described in this guide reduces the potential for erosion.

The white pine and red pine working groups generally occur on sandy soils where the potential for compaction or rutting is reduced. On imperfectly drained, clayey or silty soils, compaction or rutting can be minimized by harvesting during the winter season, when the ground is frozen. Winter harvesting can also reduce the risk of erosion on dry, shallow, hilly sites characteristic of some white pine and red pine stands.

Soil nutrient depletion from harvesting white pine and red pine is considered to be minimal because rotations are relatively long and branches and tops are left to decompose on site (Alban et al. 1976; Hendrickson et al. 1986). In a study where red pine root systems were harvested, there was no significant reduction in soil nutrient levels (Johnson 1985). The results indicated that soil nutrient status may improve as a result of precipitation inputs. Harvesting and mechanical site preparation may actually augment soil nutrients through their effect on mineralization processes (Hendrickson et al. 1986). In studies conducted at the Petawawa National Forestry Institute (PNFI), the number of species and the total biomass of herbs and shrubs increased after logging (Sidhu 1973b).

Renewal

Mechanical and chemical site preparation and prescribed burning may be applied singly or in combination in white pine and red pine renewal operations. These treatments are normally only required once in a rotation, if they are required at all (section 3.3, "Forest Renewal").

Mechanical site preparation disturbs the forest floor and exposes mineral soil on part of the total treatment area. Intermittent scarifiers can be used to reduce the potential for soil erosion on steep slopes. Severe disturbance is unnecessary to meet silvicultural objectives.

In chemical site preparation, herbicides are applied either as a directed or broadcast application to control competing vegetation. Application is by aerial or ground procedures depending on the

silvicultural system and the specifications on the herbicide label. Aerial application procedures must conform with OMNR Forest Resources Branch Procedure No. FR 04 20 10 PR (1987), *Aerial Application of Herbicides for Forest Management in Ontario*, as well as with *Aerial Spraying for Forest Management—An Operational Manual* (Carrow et al. 1981). All herbicides must be registered for use in Ontario, and label specifications must be strictly adhered to.

White pine and red pine are regenerated in nature by fire, hence prescribed burning is an effective management treatment to assist in the regeneration of these two species. Prescribed burning is conducted to reduce slash levels or to suppress or remove competing vegetation, especially balsam fir. Studies conducted at the PNFI indicate that the recovery of white pine and red pine ground vegetation communities after burning is rapid and occurs over a period of one to three years, depending on burn intensity (Sidhu 1973a,b; Methven 1973; Sidhu 1974).

On till sites characterized by steep topography, very intense burns can cause erosion and increased surface runoff. This, in turn, can lead to potential stream-channel scouring and sedimentation and the washing of ash and nutrients into water courses. However, the effects of properly conducted prescribed burns appear to be small and temporary (McRae 1986). Refer to *Prescribed Burn Planning Manual for Crown Lands in Ontario* (OMNR 1987e), *Forest Manager's Photo Guide to Prescribed Burn Planning* (Wearn et al. 1982), and the OMNR Aviation and Fire Centre Procedure No. PR AF .03 .23 .02 (1980), *Prescribed Burning* for further details related to this treatment.

Maintenance

On fresh to moist sites, tending is essential to ensure adequate survival and growth of white pine and red pine regeneration. If required, chemical cleaning to control competing vegetation may occur twice in a rotation. Herbicide use must conform to the procedures outlined in the preceding section on renewal.

Manual and mechanical cleaning, thinning, and pruning operations have minimal effects on the terrestrial environment. Early thinning and pruning treatments may improve the soil nutrient status (Hendrickson et al. 1986).

White pine and red pine are subject to damage from a variety of insect and disease pests throughout the rotation (section 2.3.6, "Damaging Agents"), and need to be protected from pest damage to achieve their full growth potential. Biological control is the recommended method of protection from damaging agents (section 3.4.2, "Forest Protection"). However, there are instances when chemical control is the only effective means of reducing pest damage. Insecticides must be applied according to OMNR Forest Resources Branch Procedure No. FR 04 10 10 PR (1987), *Aerial Application of Insecticides for Forest Management in Ontario*. The use of borax to control fomes root rot infection in red pine must conform to OMNR Forest Resources Branch Procedure No. FR 04 30 10 PR (1983), *Borax for Control of Fomes Root Rot (Fomes annosus)*. The Pest Management Section of OMNR should be consulted to obtain the most current information on the available options and the required procedures for the control of damaging agents of white pine and red pine.

3.0 MANAGEMENT PRESCRIPTIONS

Timber management is the application of a silvicultural system that operates throughout the life of the stand, rather than a series of independent treatments. Integration of harvesting with renewal is particularly important, since the method of logging affects the condition of the post-harvest site.

Management prescriptions, including harvest, renewal, and maintenance operations, are selected by the forest manager and are included in each timber management plan as silvicultural ground rules for normal operations (OMNR 1986g). Examples of active silvicultural ground rules for white pine and red pine for an officially designated Crown Management Unit in Ontario are included in Appendix V.

The forest manager develops an investment strategy and site specific silvicultural prescriptions in relation to defined management objectives. Site, stand, silvical, economic, wildlife, and environmental factors are considered in the selection of an appropriate level of investment (section 3.6, "Management Intensity") and the development of silvicultural prescriptions. Factors to consider in the silvicultural decision-making process for the management of the white pine and red pine working groups in Ontario are outlined in Figure 7.

The composition and productivity of the new forest will vary with the site condition, treatment regime, and level of treatment success. Pure, or almost pure, pine stands are expected to prevail on dry till or outwash sites. Mixedwood stands are anticipated on fresh to moderately moist till, outwash, and lacustrine sites. White spruce, red oak, poplar, or tolerant hardwoods may predominate as secondary species depending on geographic location. Without a high level of investment on nutrient-rich sites, the white pine and red pine working groups will probably convert to the poplar or tolerant hardwood working groups with a minor admixture of pine.

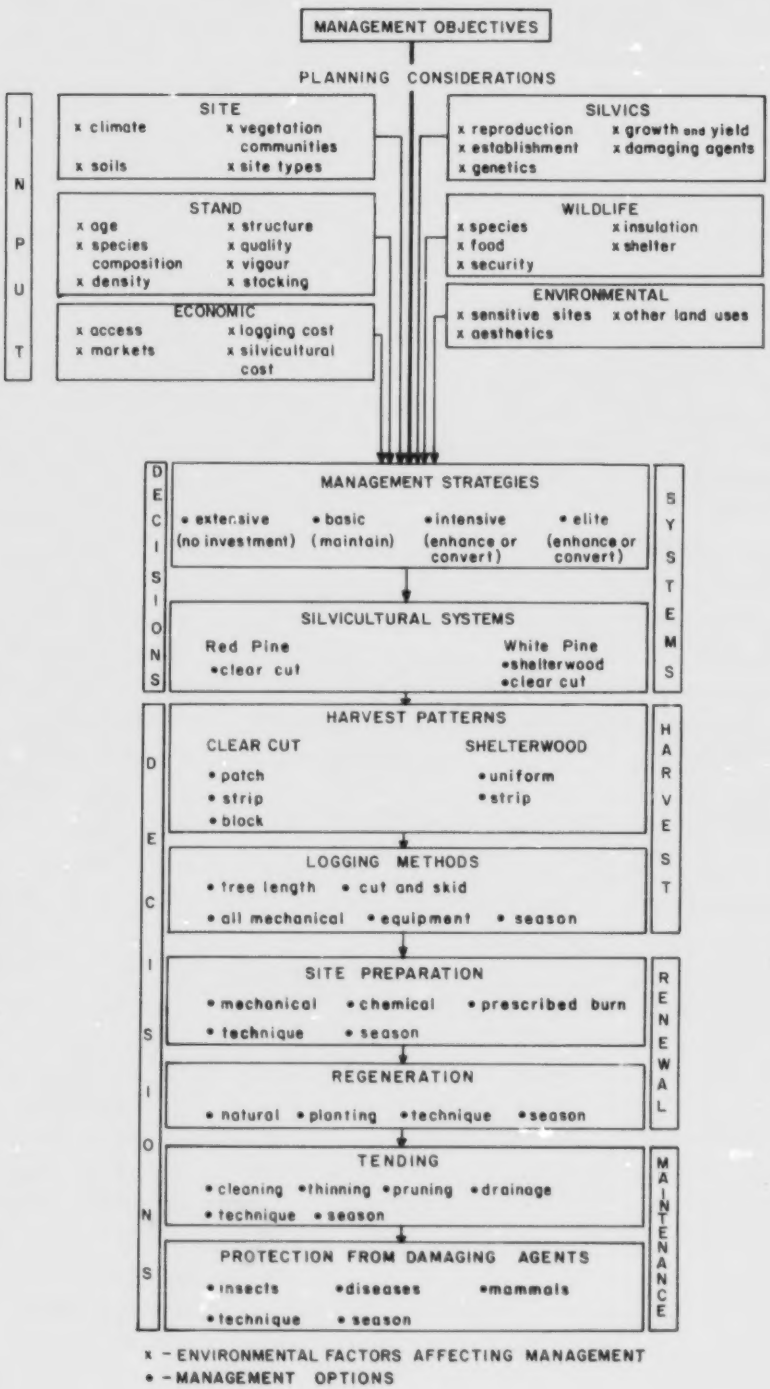
Management prescriptions are related to the four site types described in section 2.2.4, "Predominant Site Types." These four site types are:

- outwash plains
- dumped till over bedrock
- dumped till over moulded till
- lacustrine deposits

3.1 Silvicultural Systems

Silvicultural systems are classified according to the method of harvest and renewal of mature stands. In Ontario, white pine is managed by the shelterwood and clear cut systems, while red pine is managed by the clear cut system only. The shelterwood system includes uniform and strip

Figure 7: Factors to consider in the silvicultural decision-making process for the management of the white pine and red pine working groups in Ontario



harvest patterns while the clear cut system includes patch, strip, and block harvest patterns. The systems described are those currently used in silvicultural ground rules for the white pine and red pine working groups in Ontario. In areas of concern where timber management may not be the primary management objective, management and cutting practices may be modified to harvest some timber without damaging other values.

The forest manager must consider site, silvical, and stand factors along with economic, wildlife, and environmental considerations when selecting a silvicultural system. The planned sequence of treatments necessary for renewal must be decided upon at this time. It is expected that the silvicultural system selected will vary with different stand and site conditions, which will create a mosaic of stand conditions in the new forest. The main silvicultural systems applicable to the white pine and red pine working groups are described below.

3.1.1 Shelterwood System

The shelterwood system involves the gradual removal of the entire stand by a series of partial cuttings that extend over a fraction of the rotation. Natural regeneration becomes established under the protection of the older stand, which is removed as required to release the established regeneration. This system is characterized by the establishment of a new crop before completion of the preceding rotation (Smith 1962). In Ontario, artificial regeneration may be used as an alternative to natural regeneration where site and stand conditions warrant it.

3.1.1.1 Uniform Shelterwood

With the application of the uniform shelterwood system, a new stand is established under a partial canopy of mature trees, following the removal of a portion of the overstory. The overstory is usually completely removed in a series of two or more cuts. This system is widely applied for harvesting and renewing white pine (USDA 1983; Lancaster 1984; Heckman et al. 1985; Wray 1985a,b; QMER 1987) and is recommended for red pine where multiple-use objectives supercede the importance of timber production (USDA 1983).

This system is applicable in good-quality pure or relatively pure white pine stands growing on dry outwash or shallow till over bedrock sites where reliance on natural regeneration is appropriate. The shelterwood system can also be used on fresh to moderately moist sites. However, intensive site preparation to control competing vegetation, followed by planting, is usually required. Reliance on natural regeneration results in much extended regeneration periods, and many stands will convert to hardwoods with a small number of pines. Minimum stocking standards for pine may not be achieved. This system is also recommended where the management objective is the conversion of the red pine working group to the white pine working group.

Properly applied, the uniform shelterwood system can prevent or suppress the development of competing vegetation, especially shade intolerant species (e.g., aspen, white birch, and raspberry). Depending on the composition of the stand, it also provides a uniformly distributed seed

source. It facilitates germination by preventing both desiccation of the seedbed and losses of succulent seedlings from heat injury. The maintenance of shelter will also reduce the damaging impact of the white pine weevil. Shelter trees will increase in size and value while regeneration is becoming established.

This system has advantages over clear cutting where recreational use is important, because removal of the old stand is gradual and less noticeable. As well, the residual overstory will reduce the risk of erosion.

The system should be applied only where an economically viable cut can be achieved in each successive harvest. It is necessary to mark the trees designated for harvest. Careful logging is required to minimize damage to the residual stand and developing regeneration.

Three types of cuts are described here to set a framework for the application of the uniform shelterwood system: preparation, regeneration, and removal.

Preparation Cut

A preparation cut is designed to develop thrifty seed-bearers and to remove undesirable species or individuals from any position in the canopy. Dominant and co-dominant trees of good form and vigour, uniformly distributed throughout the stand, are identified and retained. White pine is favoured but good quality stems of other species can be maintained to ensure full utilization of the site. Spacing should allow for adequate crown development on residual trees, while maintaining adequate shade to discourage the development of competing vegetation. Preparatory cutting usually is scheduled in stands in the 61 to 80 year age class, when stand conditions and local markets permit. Regeneration present at the time of the preparatory cut should be protected.

Preparatory cutting is appropriate only where the seeding potential of the stand needs to be increased before the regeneration (seeding) cut is conducted (e.g., on dry till or outwash sites). Reasonably dense stands growing on sites of moderate to low timber production potential are best suited to the application of preparation cuts. Poorly stocked stands, stands that have been recently thinned, or stands dominated by species other than white pine are inappropriate to the application of preparatory cuts.

Preparatory cutting is feasible only where it is possible to retain an adequate number of good-quality seed trees well distributed over the area, while at the same time providing a viable harvest.

Regeneration Cut

The regeneration cut is specifically designed to facilitate natural or artificial regeneration. The regeneration cut is usually applied either in stands that are 81 to 100 years of age or about 20 years

after a preparatory cut has been made. Where possible, the regeneration cut should be timed to coincide with a good seed year. Good-quality dominant and co-dominant white pine should be retained as seed-bearers and site protectors. Harvesting should reduce stand density so that a minimum of 50 per cent full sunlight gets through the forest canopy. With this amount of light, seedling height growth is near the optimum level (Logan 1959), but diameter and volume growth will be substantially less than that achieved in full sunlight. Rapid crown expansion reduces the amount of available sunlight between successive harvests.

For practical purposes, crown closure can be used to approximate the percentage of full sunlight. A light meter or grid densitometer (Heckman et al. 1985) can be used to estimate per cent of full sunlight or per cent of crown closure, respectively.

Competing shrubs and hardwood regeneration should be controlled, either before a cut using prescribed fire or after a cut using herbicides. Balsam fir regeneration can be controlled prior to the cut using prescribed fire (section 3.3.1, "Site Preparation").

Removal of trees in groups can facilitate subsequent silvicultural operations, such as site preparation and planting, and may be beneficial to certain wildlife species (section 2.4, "Wildlife Considerations").

Removal Cuts

Removal cuts are scheduled to follow the successful establishment of regeneration. The timing and number of individual cuts depend on the length of the establishment period, the growth and vigour of established regeneration, the growth and value appreciation of shelter trees, and the need to moderate the impact of the white pine weevil.

Growth or vigour losses in developing regeneration must be carefully weighed against growth and value appreciation of shelter trees. Logging damage from removal cuts can be controlled, but not eliminated, through the application of minimum-damage logging techniques in felling and skidding operations (section 3.2, "Harvesting Considerations"). The least injury is likely to occur if shelter trees are harvested while the stems of the regeneration are still pliable. However, early removal may result in stem deformities as a result of the white pine weevil, especially in areas of high risk (section 3.4.2, "Forest Protection"). In these areas, maintenance of 40 per cent crown closure will provide adequate protection against this pest (Heckman et al. 1985). Under these conditions, shelter should be maintained until the regeneration achieves a total height of five metres. If canopy manipulation is used, frequent cuts are necessary.

In areas of lower risk, the overstory may be removed after the stand reaches a mean height of 1.5 m, provided that a minimum of 2000 residual stems per hectare remain uniformly distributed over the site after the final removal cut is made. Early release is the best way to achieve rapid volume production of white pine (Lancaster 1984).

3.1.1.2 Strip Shelterwood

The strip shelterwood system consists of cutting strips up to 40 m in width in an alternate or progressive fashion. Wider strips are considered to be a form of clear cut. Like the clear cut system, the strip shelterwood system calls for the removal of all merchantable growing stock on the cut area. As the name implies, uncut strips provide protection for regeneration. The amount of protection provided depends on strip width and orientation, as well as on species composition. Trees in the residual strips may serve as a seed source, depending on their seed production potential.

In Ontario, the application of the strip shelterwood system has met with limited success. Natural regeneration was unreliable on most sites where this system was applied. On dry till sites, satisfactory regeneration was obtained but establishment periods were long. Many strips were planted in an attempt to secure regeneration. However, site preparation and tending necessary to control competing vegetation was not always carried out usually because of circumstances beyond the control of the forest manager. The importance of proper site evaluation and the control of competing vegetation is apparent from these results.

Strip shelterwood is best used in white pine stands growing on relatively flat and uniform outwash plains and on till sites lacking desirable advance growth. The system is inappropriate in rugged terrain, which precludes directional mechanical operations, such as skidding, site preparation, and tending. Strip shelterwood cutting should be used in pine stands that are very dense or otherwise not well suited to the uniform shelterwood system. This system may be suitable for the conversion of low-grade hardwood stands, such as aspen and white birch, to white pine, where clear cutting is unacceptable and the costs of the uniform shelterwood system are prohibitive. It may also be an alternative to clear cutting on shallow till sites.

Regeneration can be achieved naturally on dry till sites when there is an adequate seed source. However, the regeneration period may be long and stocking levels may be low compared to those areas where the uniform shelterwood system has been applied successfully. Except on the driest sites, site preparation is necessary to control competing vegetation and occasionally to reduce slash loadings. On fresh to moist sites, intensive site preparation followed by planting is essential. Without treatment, competing vegetation, such as beaked hazel, raspberry, poplar, and white birch, may severely limit the development of regeneration on the cut strips. The development of competing intolerant vegetation is not significantly reduced by shade from the residual strips.

The harvest of residual strips is only appropriate after regeneration is successfully established on the cut strips. Established regeneration should be protected by confining harvest operations to uncut strips. The use of helicopters to apply herbicides for site preparation or tending purposes is possible where strip widths are 20 m or wider.[14]

[14]Mikkelsen, A., Unit Forester, Tweed District, OMNR, Tweed, Ontario, Personal Communication.

Strip shelterwood cuts can provide considerable protection from the white pine weevil with a minimum loss in height growth. Strips must be oriented north-south and strip width should not exceed 0.66 to 1.0 times the height of the general forest canopy. This technique is effective only where the uncut strips contain a considerable conifer component, because pure hardwood strips allow too much light through their leafless canopy during the critical spring period when adult weevils are active (Stiell and Berry 1985).

Unmerchantable conifer or hardwood trees and immature pine remaining after cutting fulfill a valuable nurse-crop role where white pine is the desired working group, especially on dry sites. Light nurse crops ranging in height from one to six metres provide the greatest benefit. This cover serves to moderate microclimatic extremes, including moisture and temperature. It also moderates the impact of the white pine weevil. The residual cover will also reduce the risk of erosion on sensitive sites and may be of value to certain wildlife species. Jack pine, larch, poplar, birch, and red oak are good nurse crops for white pine. Nurse crops should be protected during renewal and early maintenance operations if they are not suppressing the developing white pine. Poplar, in particular, may suppress white pine on fresh sites.

The strip shelterwood system is less aesthetically appealing than the uniform shelterwood system. However, it provides some site protection on shallow till sites. It may have advantages for certain wildlife species because of the size of openings created, the amount of edge-effect, the provision of strips of mature forest, and the creation of significant forest openings in close proximity (Laitin 1987).

3.1.2 Clear Cut System

The clear cut system is an even-aged silvicultural system where the entire growth is harvested over a considerable area in one operation, with or without leaving seed trees (OMNR 1986g). In this guide, the definition has been broadened to include the retention of trees for site protection and the presence of unmerchantable tree cover.

Clear cutting is the preferred silvicultural system for the management of stands to be retained in, or converted to, the red pine working group. This species is intolerant and grows poorly under a complete or partial canopy. Clear cutting is not generally recommended for the management of the white pine working group where stand conditions and access are appropriate to the application of the uniform shelterwood system. However, it can be applied in white pine stands that are poorly stocked or where damaging agents, including the white pine weevil and white pine blister rust, have substantially lowered stand quality. Clear cutting is also applicable in the conversion to white pine or red pine of hardwood or balsam fir stands growing on sites with a low timber production potential for these species. The reclamation of pine sites currently occupied by poplar or birch working groups should be given the highest priority for conversion (Robbins 1985).

White pine trees can be retained to provide a seed source and/or to provide a measure of site protection. On very shallow till sites (e.g., ridge tops), these trees may be relied upon for natural regeneration.[15] Establishment periods are usually long, up to ten years or more in length, but planting is often not justified on these sites because of limited productivity. The shelterwood system may not be applicable for economic reasons. From 10 to 35 white pine seed trees per hectare should be left well distributed on the site.

Competing trees and shrubs are abundant, especially on fresh to moist soils with a high silt content. Species such as beaked hazel, raspberry, and mountain maple are well adapted to open conditions created by clear cuts and will often rapidly colonize the site after harvest. Site preparation for competition control and for slash alignment or reduction will be necessary on many sites. Cleaning or tending is usually required on these sites after planting.

Artificial regeneration by planting is necessary on most sites, except where this investment cannot be justified because of site restrictions. In this instance (e.g., dry till sites), small edge-effect clear cuts or clear cuts with seed trees are advisable.

Logging and silvicultural operations are facilitated because tree marking is usually unnecessary (except where seed trees are retained) and residual trees do not present a physical barrier to operations. In general, clear cutting facilitates the application of the intensive silvicultural treatments prerequisite to the successful renewal of white pine and red pine stands on fresh to moderately moist sites. The application of pesticides (using either fixed-wing or helicopter aircraft) is possible, resulting in lower treatment costs than for the ground-based operations associated with the uniform shelterwood system. Prescribed burning operations are easier to conduct because the residual stand does not have to be protected, as it does in pre-cut prescribed burn operations. Fuel loadings after clear cutting may be higher because of heavier slash accumulations, making high-intensity burns feasible.

The retention of a nurse crop on cut areas helps to moderate microclimatic extremes, including moisture and temperature. It also moderates the impact of the white pine weevil. A more complete description of nurse crops and their value is provided in section 3.1.1.2, "Strip Shelterwood."

Controlled clear cuts are beneficial to certain wildlife species, including deer and moose, especially if interspersed in close proximity with untreated stands or stands subject to shelterwood or thinning treatments (Telfer 1978; Larson et al. 1986; Nyberg 1987). Shelter and food are best provided by creating a variety of conditions.

Modified patch, strip, and block clear cuts are options in the renewal of the white pine and red pine working groups. These clear cuts should be designed to facilitate access into the area for both current and subsequent harvests. Without careful planning, excessive damage to established regeneration may occur in subsequent harvests of adjacent patches, strips, or blocks. Larger cuts may be warranted in areas of salvage (e.g., wind-damaged timber). The size of the clear cut and

[15]Heikurinen, J., Consultant (formerly Regional Forestry Specialist, Northeastern Region, OMNR), Sudbury, Ontario, Personal Communication.

the width and configuration of the buffer between cuts should be based on an evaluation of stand and site conditions, with consideration given to wildlife and recreational uses, as well as to environmental values. Regeneration should be established on the cut area before buffer areas are considered for harvest.

3.1.2.1 Patch Clear Cuts

Patch clear cuts are desirable because their physical dimensions can be modified to accommodate site and stand variability. They are especially well suited to harvesting in broken terrain or in stands that lack uniformity. Patch configurations are often a reflection of the predominant mosaic in the original forest and can vary greatly in size.

Where white pine and red pine grow together naturally, the manager can favour either or both, depending on the prevailing site condition. Where the cut is matched to the site condition, subsequent silvicultural operations, especially the aerial application of pesticides, are easier to administer and deliver.

Patch clear cuts provide more edge-effect than rectangular cuts (e.g., strips, blocks), and hence are of greater value to wildlife. As well, specific stand conditions or sites can be protected.

3.1.2.2 Strip and Block Clear Cuts

Strip and block clear cuts are characterized by rectangular boundaries. Strip clear cuts are differentiated from strip shelterwood cuts by the width of the strip. Strips wider than 40 m are classified as clear cuts. Block clear cuts are rectangular, but have no specific physical dimensions. These cuts will be larger than patch cuts.

The strip or block clear cut is applicable in relatively flat, uniform terrain or where stand conditions are relatively uniform. These cuts are easier to administer than other harvest patterns. This configuration of cut should not be used until the more flexible patch clear cut is considered.

3.2 Harvesting Considerations

The tree-length, and to a lesser extent the shortwood, logging methods are used for harvesting white pine and red pine. The full-tree method is not appropriate because of the large branch diameters of both pines, but especially of white pine. Also, the value of pine favours manual bucking and individual stem attention (Silversides 1978). Branches and tops are left on site to decay.

Tree-length logging with wheeled skidders is the primary logging method used in shelterwood and clear cut silvicultural systems. The tree-lengths are normally taken to roadside landings for bucking into log lengths. Occasionally, they are directly loaded onto trucks for tree-length hauling.

Tree-length logging within the clear cut or strip shelterwood systems can cause extensive damage to residuals and advance growth. Damage to residuals and advance growth can also be significant when the uniform shelterwood system is used, depending on harvest pattern, season, terrain, skid-trail layout, and the experience of the logging crews. Correct felling and skidding techniques must be employed to minimize logging damage to residual stems and regeneration (Brace and Stewart 1974). The proper design and layout of skid-trails is essential. Skid-trails, as well as landings, can be re-used in subsequent harvests if they are well designed. Directional felling, extraction from the back of the cut to the front, winching trees to skid trails instead of backing to each tree, and the use of swing and bumper trees at turns and trail intersections is recommended (Figure 8). A small piece of skidding equipment used incorrectly can do considerably more damage than a large one used properly.

Shortwood logging is seldom used in the white pine and red pine working groups. Usually, pine stems contain more than one log length, and it is appropriate to haul out such stems intact in one trip. Shortwood logging is appropriate in rolling or broken terrain where tree-length skidding could cause unnecessary damage.

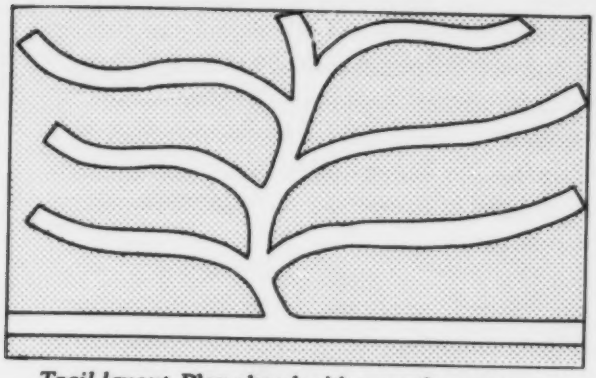
Where advance pine regeneration is absent or minimal, logging during the frost-free season will provide some mineral soil exposure as a result of skidder disturbance. It is beneficial to log part way through the growing season, when developing hardwoods and shrubs are under stress because of depleted root reserves.

Skidding during the early part of the growing season is most detrimental under uniform shelterwood, when the bark on residual pine is loose. On fresh to moist sites, long-distance skidding during the early part of the growing season may result in rutting of the site and subsequent erosion. If spring or early summer logging is unavoidable, minimum-damage logging techniques are essential to protect the residual stand. Since most lateral root development is within a few centimetres of the soil surface, care must be taken not to damage pine root systems.

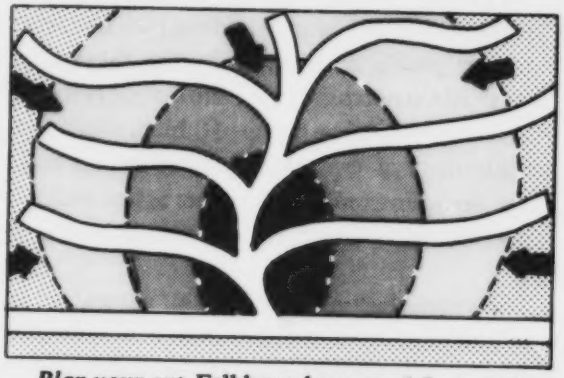
Damage to the roots and tops of advance growth and residual pine can be avoided by winter logging. Winter logging is also desirable on sites subject to erosion (e.g., rolling, steep till sites) or compaction (e.g., silty or clayey till or lacustrine sites). In areas of high summer recreational use, winter logging is an option that would serve to minimize multiple-use conflicts.

Tree-length logging requires a larger landing area than shortwood logging. Large landings may be aesthetically undesirable, and if not controlled, may occupy a significant portion of the land base. The number of landings required in an area is related to the nature of the terrain and the average skidding distance. When limited to a minimum size and number, tree-length landings provide increased control over product manufacture and quality, since they facilitate concentration of bucking by an experienced log-maker. The proper layout of landings and the transport of logs as they become available will help to minimize the area required for landings. Specialized equipment can also serve to minimize landing size. For example, the use of overhead grapple loaders will permit the operator to pile logs high, rather than wide, requiring less area. After

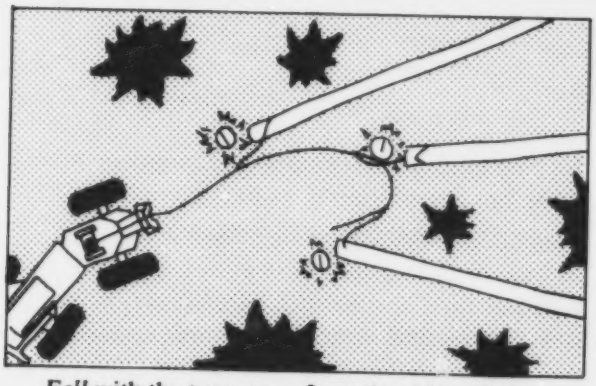
Figure 8: Minimum-damage logging techniques that can be used in the management of the white pine and red pine working groups in Ontario (adapted from a poster on minimum-damage logging techniques produced by OMNR's Algonquin Park District



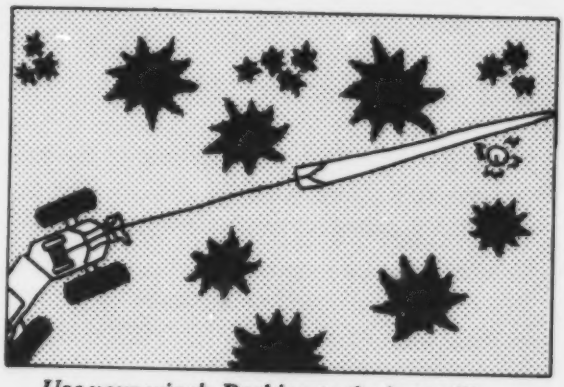
Trail layout. Plan ahead with smooth curves and easy grades.



Plan your cut. Fell boundary wood first, work towards main skid trails and landing.



Fell with the tops *away* from the skid trail for easier choking and less damage by swing.



Use your winch. Backing to the butt will damage young trees.

logging, landings can be valuable to deer and other wildlife, especially where they have been sown with forage species, such as clover.[16]

Several aids describing minimum-damage logging techniques have been developed to communicate good felling and skidding practices to woods operators. These include *The Cutting Edge* (FPAPA 1984) and video tapes produced by OMNR and the Forest Products Accident Prevention Association.

3.3 Forest Renewal

Renewal of the timber resource involves preparing the site for regeneration and regenerating the site by natural or artificial means (OMNR 1986g). Planning for renewal operations must take

[16]Quinn, N., District Biologist, Algonquin Park District, OMNR, Whitney, Ontario, Personal Communication.

place prior to the harvest to ensure adequate lead-time for the selection of a suitable harvest method, seed collection, stock production, and site preparation. An evaluation of the topography, microclimate, soils, and vegetation communities is essential when planning for renewal operations. Productivity relationships (e.g., height/age) also provide useful decision-support information. White pine and red pine renewal should be emphasized on areas of moderate to high timber production capability for these species, but not on those sites with a high timber production potential (e.g., site class 1 [Plonski 1981]) for tolerant hardwoods. Priority should be given to renewal on dumped (ablation) till and outwash sites. These sites should be stratified with the biological requirements of white pine and red pine in mind. In this manner, timber production can be optimized and the costs associated with the control of competing vegetation, damaging agents, and re-treatment operations can be minimized (section 2.2, "Site").

The regeneration method (e.g., natural or artificial) should be chosen when the silvicultural system is selected. The type and intensity of site preparation depends on the site, the silvicultural system, and the regeneration method. Condition assessments should be carried out to determine the need for the control of competing vegetation and damaging agents, especially during the establishment period.

3.3.1 Site Preparation

Site preparation is the disturbance of the forest floor by mechanical or chemical means or by prescribed burning (OMNR 1987b). The purpose of site preparation is to create conditions suitable for natural or artificial regeneration. The objectives of site preparation are summarized as follows:

- to suppress competing vegetation (e.g., grass, shrubs, and competing tree species);
- to create microsites suitable for regeneration by mixing mineral soil and organic material where appropriate;
- to cause the reduction, removal, or alignment of slash; and
- to allow easier control over the spacing of trees.

Mechanical, chemical, or prescribed burn treatments can be applied singly or in combination, depending on site conditions. The management of vegetation communities to favour pine is an essential component in site preparation. The treatment objective is to reduce the abundance and vigour of competing vegetation during the critical establishment period.

3.3.1.1 Mechanical Site Preparation

Mechanical site preparation is essential for reducing or aligning slash. Slash can form a physical barrier to regeneration and can serve as an impediment to subsequent silvicultural operations.

Mechanical site preparation is also used to create a favourable microsite for natural or artificial regeneration.

The selection of equipment should be based on a consideration of the following factors:

- harvest method (e.g., shelterwood or clear cut);
- characteristics of the residual stand;
- topography;
- soil characteristics;
- ground overburden (e.g., thickness of the organic layer or amount of slash loading);
- planned follow-up silvicultural prescriptions;
- intensity of treatment required;
- comparative costs; and
- environmental considerations.

Mechanical site preparation is conducted soon after the harvest cut operation. The effectiveness of logging scarification and the amount and distribution of logging slash must be considered in the preparation of a treatment prescription. The depth of the organic layer is an important consideration as well. This layer is often thick under stands dominated by conifer species growing on fresh to moist sites. A summary of mechanical equipment that has been used successfully in renewal operations in the white pine and red pine working groups in Ontario is provided in Table 5.

Care must be taken to prevent excessive scalping or transport of mineral soil. Excessive exposure of mineral soil may lead to erosion on steep slopes or frost heaving of seedlings in soils with a high content of silt or clay.

The silvicultural equipment reference catalogues for northern and southern Ontario are useful in selecting mechanical site preparation equipment (Smith 1980; Smith 1981). In addition, Smith (1987) has prepared a summary of current uses and trends in mechanized site preparation technology applicable to Ontario conditions.

3.3.1.2 Chemical Site Preparation

Herbicides are used to suppress grasses, herbs, shrubs, and trees that are providing moderate to severe competition for the pines. They can be applied as a selective or blanket treatment, and they

TABLE 5: Mechanical Site Preparation Equipment Commonly Used in the Renewal of the White Pine and Red Pine Working Groups in Ontario

Equipment	Silvicultural System	Function	Limitations
Hydro-axe	Clear cut	Used to mow shrub and tree vegetation of moderate to high density (e.g., poplar, willow, or alder) Applicable to productive, stoney soils	Productivity is a function of mean diameter, density, and stocking of vegetation Where mean diameter is small (< 2 cm), small rear-mounted brush cutters are applicable
Young's teeth	Clear cut Shelterwood	Removal or alignment of slash Some exposure of mineral soil	Very large boulders can cause damage to the teeth
TTS disc trencher and leno patch scarifiers (both powered and regular)	Clear cut Shelterwood	Used to expose mineral soil in patches at intervals; patches serve to guide tree planters where artificial regeneration is used Useful where erosion may be a concern	Not effective where there is a buildup of slash
Small tracked bulldozers with 6-way blades (under 70 net horse power)	Uniform shelterwood	Exposes and mixes mineral soil with organic matter	Not effective where there is a buildup of slash
Eden rake	Clear cut	Used for the alignment of logging slash or budworm-killed balsam fir	Not applicable where logging slash accumulations are heavy or residual tree cover is heavy
Blade rake	Clear cut	Used for the alignment of heavy accumulations of logging slash or dense budworm-killed balsam fir	Approximately 20 per cent of the area is lost to windrows More suitable to red pine renewal because disburbance is more intensive
Straight blades	Clear cut	Used to clear away shrubs, small residual trees, and logging slash	Care must be taken not to cause excessive disturbance of the topsoil
Large bulldozers (e.g., D-7) skidder blades	Clear cut	Used to tramp heavy shrub or tree undergrowth, including heavy balsam fir Used as a pre-treatment for prescribed burning May be followed by a herbicide treatment where there is a hardwood component	Not applicable on shallow till sites

can be used in combination with a mechanical site preparation treatment where conditions warrant.

The following factors must be considered in selecting and scheduling herbicide treatments:

- species of target vegetation;
- type of application—selective or broadcast;
- method of application—aerial or ground;
- proper registration—herbicides must be registered for the specific operational use (specific formulation, rates, target vegetation, ground versus aerial, etc.);
- weather conditions required for effective treatment;
- potential for soil residues;
- planned follow-up silvicultural prescriptions;
- operational logistics;
- comparative costs; and
- environmental considerations.

At present, the herbicides 2,4-D, glyphosate, hexazinone, and simazine are registered for use in site preparation operations prior to the establishment of white pine or red pine. Formulations of both 2,4-D and glyphosate are presently registered for aerial and ground applications in Ontario. Information pertinent to the operational use of these herbicides in white pine and red pine management is summarized in Table 6.

Glyphosate and 2,4-D are not recommended for aerial application where the uniform shelterwood system is applied. The effect of these two herbicides on a pine overstory is unknown and penetration through the upper canopy is difficult to achieve. As well, desirable hardwoods in mixedwood conditions may be killed or suppressed. Glyphosate and 2,4-D have been successfully applied by helicopter where the strip shelterwood system has been used in the conversion of unmerchantable hardwood stands to pine. A single-pass application with 20 m strips is favoured.[17] Hexazinone and simazine are not approved for aerial application and can be used for ground application only.

Where the clear cut system is used, 2,4-D or glyphosate can be applied for purposes of drying fuel or reducing the amount of living vegetation on a site, allowing for a more complete burn coverage. These treatments may also be applied before or after mechanical site preparation to suppress competing vegetation.

[17]Mikkelsen, A., Unit Forester, Tweed District, OMNR, Tweed, Ontario, Personal Communication.

TABLE 6: Information to Assist in the Selection and Use of Herbicides for Site Preparation in the Renewal of the White Pine and Red Pine Working Groups in Ontario

Herbicide	Soil Type(s)	Target Vegetation	Herbicide Formulation	Application Criteria	Crop Tolerance
2,4-D	No restrictions	Poplar, birch, cherry, dogwood, willow, elderberry, etc.	The ester is the only formulation registered for forestry use	Aerial or ground application Most effective when applied in late spring or early summer after full leaf development Thoroughly wet stems and foliage to the point of run-off	Will kill or suppress white pine and red pine during the period of active growth
Glyphosate	No restrictions	Broad-spectrum control (perennial grass, poplar, birch, maple, cherry, raspberry, etc.)	Vision is the only formulation registered for forestry use	Aerial or ground application Apply to actively growing vegetation in early spring or late summer and early fall	Will kill or suppress white pine and red pine during the period of active growth
Hexazinone	Should not be applied on soils with less than 2 per cent organic matter	Grasses, raspberry, poplar, birch cherry, maple ash, etc.	Velpar	Ground application only For grass and herbs, apply broadcast in the spring before the leaves are fully expanded For shrub and tree control, apply directly to soil within 0.5 m of target vegetation	White pine is very susceptible to damage, but red pine is quite tolerant Application rates must be very precise
Simazine	Highest rates are required on fine-textured soils and soils high in organic matter	Annual grass, germinating perennial grass, and triazine-sensitive herbs	Varied	Ground application only Most appropriate on lands formerly under agricultural cultivation Apply broadcast or selectively in spring or in fall before freezeup	White pine can tolerate higher rates than red pine can Container stock of both species is more susceptible to damage than bareroot stock is because of shallower root position

More detailed information on application techniques and rates should be obtained by reviewing the manufacturer's label and through discussion with staff in the OMNR Pest Management Section and with other practitioners. The aerial application of herbicides should conform with OMNR Forest Resources Branch Procedure No. FR 04 20 10 PR (1987), *Aerial Application of Herbicides for Forest Management in Ontario,* as well as *Aerial Spraying for Forest Management—An Operational Manual* (Carrow et al. 1981). In addition, reference can be made to *Guide to Chemical Weed Control* for information on various herbicides. This document is published annually by the Ontario Ministry of Agriculture and Food, and the information applies primarily to agricultural crops.

3.3.1.3 Prescribed Burning

In the natural ecosystem, the perpetuation of both white pine and red pine is largely dependant on disturbance, usually fire, coupled with an adequate seed supply (Methven 1973) (section 2.3, "Silvics of White Pine and Red Pine"). Fire creates microsite conditions favourable to the establishment of both pine species. Therefore, prescribed burning offers a useful silvicultural technique which creates conditions favourable to white pine and red pine establishment.

The principle objectives of prescribed burning are:

- to prepare the site for natural or artificial regeneration (e.g., organic layer reduction, mineral soil exposure, slash reduction); and,

- to reduce or suppress competing vegetation, especially shrubs, and undesirable tree species.

Prescribed fire will kill shrubs as well as immature trees up to 10 cm DBH by girdling the cambium. As a result, the relative abundance and vigour of competing shrubs (e.g., beaked hazel, mountain maple, raspberry, and blueberry) may be reduced for several years by prescribed burning (Sidhu 1973a; Methven 1973). Shrub and tree species are often replaced by herbs that are far less competitive (Methven 1973). Very competitive shrubs, such as raspberry, may be replaced by aspen suckers after an intense burn. Aspen suckers thin rapidly and height growth slows appreciably, which favours the development of white pine seedlings. This trend is most apparent on dry, nutrient-poor sites. Balsam fir can be eliminated by one fire of light intensity, but shrubs and undesirable hardwood trees require two fires for best results. In this case, the first fire should be scheduled before leaf flush and the second fire should be scheduled in the second year, after leaf flush.

A single burn followed by a herbicide application a year or two later provides a method of vegetation control that is just as effective as two prescribed burns. The prescribed burn lowers the foliage to ground level (i.e., new sprouts) thereby making access much easier and the vegetation more susceptible to herbicides.[18]

[18]Methven, Dr. I.R., R/EMS Research Limited, Fredericton, New Brunswick, Personal Communication.

Where the understory is comprised of deciduous species, fire behaviour is uniform and predictable and control is relatively easy. Balsam fir complicates fire behaviour, depending on its size and degree of uniformity over the treatment area.

Two types of prescribed burning are applicable in white pine and red pine operations; the pre-cut burn (Van Wagner and Methven 1977), and the post-cut burn. The pre-cut burn is applicable only where the uniform shelterwood system is used. Burning should be conducted just prior to the regeneration cut (section 3.1.1, "Shelterwood System"). It should be scheduled to coincide with a good seed year, especially where natural regeneration is being relied upon.

Pre-cut Burn

Pre-cut burning is only applicable in pine stands which are 80 years of age or older. Younger trees may be damaged or killed by hot convection gases. A properly implemented prescribed burn will result in minimum damage to the stem and crown of shelter trees, with no significant effect on subsequent growth rate. The burn intensity should correspond with a flame height of one metre or less. Pre-cut burns should not be used where there is a uniform or clumped occurrence of balsam fir in the understory. The fuel load associated with this condition may lead to scorching of shelter trees (Van Wagner and Methven 1978). Pre-cut burning is not recommended where there is a merchantable component of hardwood in the stand because charred timber is not suitable for pulping.[19]

Post-cut Burn

Post-cut burning creates a higher intensity fire and is most applicable where clear cutting is followed by planting of either white pine or red pine. It may also be used three or four years after the regeneration cut in uniform shelterwood operations, where slash levels are reduced as a result of decay and initial regeneration attempts have been unsuccessful. This burn is commonly applied in conversion operations, especially where there are heavy accumulations of logging slash. Damage to residual trees within the burn perimeter is less critical with this type of burn. Special precautions to protect trees are unnecessary except where seed or shelter trees are retained.

The burning of very shallow till sites is not recommended because of the subsequent potential for erosion. Also, the heat drawn to the resulting dry, blackened surfaces can damage developing pine regeneration.

A detailed plan is required well in advance of prescribed burning. Procedures for planning prescribed burns are described in *Prescribed Burn Planning Manual for Crown Lands in Ontario*

[19] Honeyborne, D., Forester, Central Ontario Forest Technology Development Unit, OMNR, North Bay, Ontario, Personal Communication.

(OMNR 1987e). Additional references include the OMNR Aviation and Fire Centre Procedure No. PR AF .03 .23 .02 (1980), *Prescribed Burning* and *Forest Manager's Photo Guide to Prescribed Burn Planning* (Wearn et al. 1982). Specifically, the upland mixedwood site types in the photo guide (e.g., poplar, birch, balsam fir, and spruce) may represent conditions similar to sites where a conversion from intolerant hardwood to pine is scheduled. The Canadian Forest Fire Prediction System now contains rates of spread equations for pine. Fuel consumption and intensity equations will soon be available.[20]

3.3.2 Regeneration

White pine may be regenerated using natural or artificial techniques depending on site, silvical, and economic factors. Planting is the only successful method of regenerating red pine.

3.3.2.1 Natural Regeneration

Mature stands of white pine produce abundant cone crops at three- to five-year intervals. In older stands, the frequency of abundant cone crops tends to be less. The size of the cone crop cannot be predicted until one year prior to cone maturity (section 2.3, "Silvics of White Pine and Red Pine"). Since harvests are scheduled annually, it is seldom possible to organize operations to coincide with a good seed year.

Reliance on natural regeneration for white pine renewal is appropriate on dry, sandy outwash or till sites where competing vegetation is not vigourous. Natural regeneration usually seeds in over a number of years. The uniform shelterwood system can provide ample regeneration and shelter on these sites if applied properly. The strip shelterwood system and clear cut with seed trees system are much less reliable because seed is less abundant and microclimatic extremes affecting establishment are more variable. Also, competing vegetation, especially intolerant species, is usually more abundant where the overhead canopy is removed. Minimum stocking standards can be met using the strip shelterwood system and clear cut with seed trees, but establishment periods may be ten years or more in length. The seed source may include inferior phenotypes because the poor quality trees have not been removed from the remaining strips.

Natural regeneration of white pine is not dependable on fresh to moderately moist sites, regardless of the soil texture, the site type, or the silvicultural system used, because of the competition from shrubs and herbaceous vegetation. Competition is particularly severe on nutrient-rich sites.

Reduction of the hardwood component in mixedwood stands will favour establishment of white pine because first-year seedlings are susceptible to smothering by hardwood leaves (Stiell 1978; Heckman et al. 1985).

[20]Methven, Dr. I.R., R/EMS Research Limited, Fredericton, New Brunswick, Personal Communication.

3.3.2.2 Direct Seeding

Attempts to direct seed white pine and red pine usually have been unsuccessful (Horton and Bedell 1960; USDA 1983; Stiell 1985). Stocking is generally erratic, requiring subsequent costly treatment. In addition, seed procurement for the large amounts of seed required is difficult and costly.

3.3.2.3 Planting

Site Selection

Proper site selection for white pine and red pine is a very important first step in planning and implementing planting programs (see section 2.2, "Site"). Planting is the usual method of regeneration for both pines on clear cut areas, except where seed trees (for white pine) are relied upon. Planting may also be used on all lands converted from other working groups (e.g., poplar, birch) and on unused agricultural land.

Planting is the preferred regeneration method for white pine on sites where the soil moisture regime is fresh to moderately moist, regardless of the silvicultural system. Moderate to severe levels of competing vegetation are characteristic of these sites. White pine planting stock has a very high probability of becoming established if competing vegetation is controlled. Besides avoiding the difficulties associated with uncertain seed years and germination, planting stock has a decided competitive advantage over natural regeneration. With management, at least one metre in height growth is achievable in five to seven years. In contrast, the establishment period for natural regeneration is eight years or more.

Planting is the only reliable method for regenerating red pine on all sites because of its irregular and infrequent seed years. The species produces very little seed in parts of the north because of climatic limitations. In addition, developing seedlings are extremely sensitive to the effects of competing vegetation.

White pine can be grown successfully in all blister rust hazard zones but should not be planted on sites where the risk of blister rust damage is locally severe. In areas of high risk for white pine weevil, such production strategies as the use of a nurse crop are beneficial. Light nurse crops one to six metres in height are recommended. Red pine should not be planted on sites where the risk of infection by scleroderris canker is high (see section 2.3.6, "Damaging Agents").

Planting Stock

White pine is usually produced as 3+0 or 2+1 bareroot nursery stock. It is also produced on a limited basis as dormant container stock or as accelerated transplants (e.g., G+1, G+2). For accelerated transplant stock, the number of viable seeds required for each tree produced is less and valuable seed will extend further. Transplant seedlings should be reserved for sites with the highest potential for re-invasion by competing vegetation (Mullen and Howard 1973). Container stock is recommended for sites where vegetative competition is expected to be less of a problem.

Red pine is produced primarily as 3+0, 2+0, and 1+2 bareroot stock. Large container stock is grown in Northeastern Region. In the past, outplanted 3+0 red pine stock has not performed as well as transplanted stock, on the average (Glerum and Paterson 1985). This has led to the development of suitable 2+0 stock which has replaced 3+0 stock in some areas. However, recent changes in nursery cultural technologies (especially the application of root pruning and root wrenching) have resulted in better balanced 3+0 red pine. Early indications are that the field performance of the 3+0 product has improved but field trials to test this have just been initiated.[21] The decision to plant 2+0 or 3+0 stock must be based on the morphological and physiological quality of individual stock lots.

In recent years, production of white pine and red pine container stock using very short rotations has gained momentum because of the flexibility provided in the delivery of field programs and in stock production. With shorter rotations, some imbalances in the supply and demand of nursery stock can be overcome. Container stock can be tailored to local operational and site requirements and is easier to plant than bareroot stock on shallow or stony till sites.

Technology to produce white pine as overwintered, frozen-stored bareroot stock has been developed and is currently being used in operational programs on a limited basis. In some regions, spring lifting of stock is delayed because nursery soils are frozen, yet conditions for outplanting are optimum. Delayed planting is undesirable because of the potential for late-season moisture deficits, especially in southern and northwestern Ontario. Overwintered stock has an advantage over fresh lifted stock where these conditions occur.[22]

Bareroot stock production standards have been developed for white pine and red pine. They may vary somewhat from region to region, depending on the prevailing site conditions.

Season of Planting

Spring planting is recommended for both white pine and red pine with timing largely determined by regional climate. In southern Ontario, planting may commence in early April, while in Northeastern Region conditions may not be favourable to start-up until May. Planting should not take place until soil temperatures reach 5°C. Planting of containers as late as July has provided acceptable results in Northeastern Region, but is not recommended in southern Ontario and in Northwestern Region because moisture deficits are common at this time of year, especially on dry sites.

Plantation Design

In most cases, the planting of white pine and red pine in single species patches, blocks, or strips of varying sizes is recommended. Where the risk of white pine weevil damage is high, the incorporation of a nurse crop (e.g., jack pine or larch) will lessen the impact of the insect and will

[21] Glerum, Dr. C., Research Scientist, Ontario Tree Improvement and Biomass Institute, OMNR, Maple, Ontario, Personal Communication.

[22] Campbell, A., Superintendent, Kemptville Nursery, OMNR, Kemptville, Ontario, Personal Communication.

provide for a degree of site amelioration. The incorporation of a shorter rotation nurse crop with the longer rotation white pine may provide an earlier economic return from the planted area. Plantations should be designed to facilitate easy removal of the nurse crop when it is mature. Alternately, exposed sites in areas of high weevil risk may be planted to red pine or jack pine with the intention of incorporating white pine into the next rotation. This strategy is particularly appropriate on dry sites. Another approach, on dry sites, is to plant white pine one to two years after site preparation to allow some protective vegetative cover to establish. This cover will help to ameliorate the microclimate for the establishing white pine seedlings.

Initial Spacing

Planting permits a degree of control over stocking and density. Individual tree volume growth of white pine and red pine is inferior when they are grown at very high densities, and costly pre-commercial thinnings may be necessary. The effect of initial spacing on stem quality should be carefully considered.

Current practice is to plant white pine at spacings ranging from 1.5 m x 1.5 m to 3.0 m x 3.0 m. Close spacings are recommended where risk of weevil damage is high (e.g., on open sites where the microclimate and soils are dry) and where pre-establishment losses are expected to be significant. Wider spacings are recommended on productive sites where the risk of weevil damage is low and pre-establishment losses (e.g., losses to drought and logging damage) are expected to be minimal. Pruning will be essential where wider spacings are used.

For red pine, the current practice is to plant at spacings ranging from 2.0 m x 2.0 m to 2.4 m x 2.4 m. It is recommended that the wider spacings be used, except on sites where pre-establishment losses are expected to be significant (e.g., exposed dry or stony sites or where site preparation was not adequate).

Initial spacing is one factor affecting the level of silvicultural investment required over the rotation. While the establishment of wide-spaced plantations requires a lower investment in stock production and planting, pruning may be more costly because self-pruning is less effective and mean branch size is larger. Conversely, closer spacings may necessitate higher investments in pre-commercial thinning. A square spacing is not critical, since it may be desirable to establish a wider spacing in one direction to facilitate early maintenance operations. Economic analysis can help to determine spacings appropriate for specific conditions.

3.3.2.4 Free-to-grow Standards

When a forest stand is considered established it is in a free-to-grow condition. It may then be reclassified into the production base of the Forest Resource Inventory.[23]

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[23] OMNR, Forest Resources Branch Policy No. FR 14 01 01 PO (1988), *Regeneration Effectiveness and Free-to-grow Declaration*.

A stand must meet the following criteria to be considered free-to-grow:

- have a minimum stocking level;
- have a minimum height requirement; and
- be essentially free of competition that impedes growth.

Regional free-to-grow standards for white pine and red pine have been developed for the regions in which these species are considered to be commercially important (Table 7). These standards set the minimum acceptable criteria and levels for the establishment of white pine and red pine regeneration. In most cases, secondary species that may be included in a determination of stocking per cent are shown. Other species, including poplar, birch, and hemlock, may be a viable component of the developing stand, but are not included in a determination of free-to-grow stocking. Stands that do not meet the free-to-grow criteria can be re-treated, placed in the production base of the forest resource inventory as a different working group (e.g., poplar), or rejected from the production base of the inventory. It must be recognized that long-term success is not assured at this stage. A commitment to management throughout the rotation will be necessary if high-value stands are to be grown.

3.4 Stand Maintenance

Forest stand maintenance includes those operations undertaken to ensure the continuation and development of established forest cover (OMNR 1986g). For the purposes of this guide, this definition has been expanded to include tending during the pre-established phase as well. Scheduling of appropriate and timely maintenance activities in white pine and red pine stands is essential. The quantity and quality of timber produced and the time it takes to reach financial maturity depend on the level of maintenance conducted over the rotation (Irland 1985; Marty 1985; Smith and Seymour 1985).

Pest management must be an integral part of stand maintenance. For example, strategies such as proper site selection can help to produce forest stands that are less susceptible to damage from insects and diseases. Where appropriate, it may be possible to modify maintenance practices to enhance other forest values such as wildlife. For example, high thinning intensities may lead to the development of browse for local deer populations.

3.4.1 Tending

Both white pine and red pine respond well to a number of tending treatments, including cleaning, thinning, stand improvement, and pruning. Investments in site preparation are protected through the timely scheduling of mechanical, chemical, or manual cleaning treatments. The harvest method, the amount of competing vegetation, and the effectiveness of site preparation treatments

TABLE 7: Free-to-grow Standards* for White Pine and Red Pine by OMNR Administrative Region

Region	Forest Unit	Renewal Treatment	Minimum Stocking (%)	Stocking Objective(%)	Acceptable Species	Minimum Total Ht(m)	Assessment Timing (yrs)
Northwestern	Pr[a]	Plant	> 40	> 60	Pr	1.0	5-10
		Natural	> 40	> 50	Pr	1.0	5-10
	Mixed conifer	Plant	> 40	n/a	S,Pj,Pw,Pr,L	1.0	8-12
		Natural	> 40	n/a	S,Pj,Pw,Pr,L	1.0	8-12
North Central	Mixed conifer	Plant	> 40	> 70	S,Pj,Pr	1.0	6
		Natural	> 40	> 40	B,S,Pj,Pr,L	1.0	7
Northern	Not listed						
Northeastern	Pr	Plant	> 40	> 70	Pj,S,Pr,other	1.0	Not specified
		Natural	> 40	> 60	Pj,S,Pr,other	1.0	Not specified
	Pw	Plant	> 40	> 70	Not specified	1.0	Not specified
		Natural	> 40	> 60	Not specified	1.0	Not specified
Algonquin	Pw	Plant - shelterwood	> 40	> 60 > (40-Pw)	Pw, Pr, Sw, Sr, Or	1.0	5-10
		Natural	> 40	> 60 > (40-Pw)	Pw, Pr, Sw, Sr, Or	1.0	10
	Pr	Plant - clear cut, barren and scattered	> 50	> 60 > (40-Pr)	Pr,Pw,Sw,Sr	1.0	5-7
		Natural	> 40	> 60 > (40-Pr)	Pr,Pw,Sw,Sr	1.0	7
	Pw,Pr	Plant-shelterwood	> 40	> 60 > (40-Pw/Pr)	Pw,Pr,Sw,Sr	1.0	5
Eastern	Pw	Plant - clear cut, barren and scattered	> 70 (Pw predominant)	> 80 (Pw predominant)	Pw,Pr,Pj,L	1.0	5-7
	Pw	Plant - shelterwood	> 60 (Pw predominant)	> 80 (Pw predominant)	Pw, Sw, Or, Mh, Aw	1.0	5-7
	Pw	Natural	> 50 (Pw predominant)	> 70 > (40-Pw)	Pw, Pr, S, Or, Mh, Aw	1.0	8
	Pr	Plant - clear cut, barren and scattered	> 60	> 80	Pr,Pw,S	1.0	5
Central and Southwestern	Pw,Pr	Plant - barren and scattered	> 60	Not specified	Not specified	1.0	5
	Pw,Pr	Plant - shelterwood	> 40 (planted species)	Not specified	Not specified	1.0	5

*OMNR, Forest Resources Branch Policy No. 14 02 01 PO (1988), *Regional Free-to-grow Standards*

[a]Pr = Red Pine
Pj = Jack Pine
Sw = White Spruce
S = Spruce
Or = Red Oak
Mh = Hard Maple
Pw = White Pine
Pr = Red Pine
L = Larch
Sr = Red Spruce
B = Balsam Fir
Aw = White Ash

determine the need for cleaning. Thinning and improvement operations are a benefit to both species by increasing growth on the remaining trees. The quality of crop trees of white pine and red pine can be significantly enhanced through well-timed pruning. Management considerations related to tending activities are summarized in Table 8.

3.4.1.1 Cleaning

Cleaning is an operation carried out in young stands, not past the sapling stage, to free trees from undesirable individuals of similar age or size which overtop them or are likely to do so (OMNR 1986g). Cleaning can be accomplished by chemical, mechanical, or manual means. Condition assessments should be conducted to establish the necessity and timing for cleaning treatments. The scheduling of cleaning treatments depends on site conditions, original stand composition, and effectiveness of site preparation. Early release is a critical determinant of plantation survival and growth for both white pine and red pine. Several well-timed release treatments may be necessary to ensure successful establishment, especially on fresh to moderately moist or nutrient- rich sites. In some cases, it may be desirable to delay cleaning until the young pines are capable of rapid height growth at which time fewer, well-timed treatments would be necessary to ensure regeneration success.

In the early years, white pine will benefit from some lateral or overhead shading, especially on dry sites. On these sites, vegetation that has developed after site preparation should not be removed unless it is interfering directly with the growth of the pines. Where a nurse crop is used for white pine, competition should be selectively removed while still maintaining the benefit of some cover. A white pine seedling or sapling with a full, healthy crown extending 50 per cent or more of its total height and with a constant leader extension will respond almost immediately to release. The response is much slower where trees possess small, sparse crowns (Lancaster 1984) with diminishing leader extension for the previous two or more years. Red pine is very sensitive to lateral or overhead competition because of its shade intolerance. Early release treatments are essential for this species.

Both 2,4-D and glyphosate can be applied in cleaning operations to control competing vegetation. Aerial or ground application may be appropriate, depending on size of the treatment area, access, and the harvest pattern. These treatments should be scheduled after white pine and red pine crop trees have set bud and hardened off. Spot applications of hexazinone can be applied at or near budbreak until early summer to release red pine. Application is most effective in the spring after the ground has thawed.

Perennial grasses can be controlled with glyphosate, while simazine is used to control annual grasses and triazine-sensitive weeds. An artificial shield must be used when the trees are in the non-dormant stage to ensure that the pine trees are protected from damage by these herbicides.

Mechanical or manual methods of cleaning may be appropriate in some circumstances. Where possible, these treatments should be scheduled when root reserves of competing vegetation are lowest, usually from mid-June to August.

TABLE 8: Guidelines for the Development of Maintenance Schedules for the White Pine and Red Pine Working Groups in Ontario

Tending Activity	Applications	Management Considerations	
		White Pine	Red Pine
Cleaning	In young stands, especially where the soil moisture regime is fresh to moist or soils are nutrient-rich Condition assessments are essential to determine the need for treatment and timing Target competing vegetation should be identified	On dry sites, white pine will benefit from some cover afforded by associated vegetation Leader clipping may be scheduled at the same time that cleaning is carried out	Red pine is very intolerant of shade provided by grass, herbs, and shrubs Hexazinone may be applied to red pine at or near bud break until early summer
	At least one cleaning treatment will be necessary on fresh to moist or nutrient-rich sites In some cases, treatment may be delayed until the pines are capable of rapid height growth response	2,4-D and glyphosate applications should be scheduled after bud set for both white pine and red pine Manual or mechanical treatments should be scheduled when the root reserves of competing vegetation are low	
Thinning	In dense immature stands of white pine and red pine First thinnings are usually non-selective (e.g., row removal) Crop trees are usually not marked until after the first thinning A minimum of 250 crop trees per hectare should be selected and marked for retention after the first thinning	Basal area should be reduced to 23 to 25 m^2/ha in first thinnings and to 30 to 35 m^2/ha in subsequent thinnings Thinning is beneficial when the live crown ratio decreases to less than 40 per cent	
		White pine can withstand dense conditions better than red pine can because it is moderately shade tolerant	Red pine will develop tall, spindly stems when dense stands are not thinned
Improvement	In mixedwood stands In plantations where stand quality is variable or where there is a component of hardwood Thinning may be a component of any improvement activity	White pine will respond well to release where suppression has been light to moderate for many years	Red pine will not respond well to release where the trees have been overtopped for extended periods
Pruning	Only crop trees should be pruned Pruning should be scheduled as soon as possible after thinning or improvement operations 40 per cent of the bole should be maintained in live crown Priority for pruning should be given to stands growing on productive and accessible lands	Both white pine and red pine exhibit poor natural pruning	
		In dense stands, the lower branches of white pine die and are retained for many years	In dense stands, red pine is a better self-pruner than white pine

Release treatments may be necessary where there is a hardwood overstory. For white pine, approximately 50 per cent full sunlight is necessary to ensure an appropriate growth response (section 2.3, "Silvics of White Pine and Red Pine"). Complete release from overstory competition is recommended for red pine.

Stem injection methods or manual girdling are effective for the liberation of white pine and red pine from a dense overstory. The stem injection method is most effective in late summer or fall. Vision and Tordon-101 are registered for this use.[24]

Herbicide application must conform to OMNR Forest Resources Branch Procedure No. FR 04 20 10 PR (1987), *Aerial Application of Herbicides for Forest Management in Ontario* as well as *Aerial Spraying for Forest Management: An Operational Manual* (Carrow et al. 1981). All herbicides must be registered for use in Ontario and label specifications must be strictly adhered to.

3.4.1.2 Thinning

Thinning is undertaken to increase diameter growth of crop trees in the residual stand and to improve stand quality (OMNR 1986b). In commercial operations, thinning permits the utilization of trees that would die from suppression or other causes if the stands were left untreated. Ground vegetation (e.g., herbs and shrubs) may develop at higher levels of thinning intensity, which may be of value to some wildlife species. Also, thinning facilitates access into stands for recreational activities and eliminates the visual impact of rows of trees in plantations. The timing of thinnings in white pine is less critical than for red pine owing to its greater shade tolerance and its greater capacity for crown canopy differentiation (Chapeskie 1983; Cooke and Barrett 1985; OMNR 1986d). If white pine is not thinned, however, there is steady mortality of co-dominant and lower crown classes, and diameter growth is greatly diminished (Stiell 1979; Cooke and Barrett 1985; Leak 1985). If red pine is left unthinned, diameter growth is greatly reduced, and it will develop tall, spindly stems that are susceptible to storm damage. Response to thinning at this stage of development is minimal.

Many red pine plantations established at initial spacings ranging from 1.0 m x 1.0 m to 1.8 m x 1.8 m and dense stands originating from natural regeneration benefit greatly from thinning. This operation should be scheduled when the stands are about 15 to 20 years of age. In regularly spaced plantations, row thinning with establishment of access for subsequent operations is desirable at this stage (OMNR 1986d).

In stands 20 to 40 years of age, first thinnings can be selective thinnings, row thinnings, or a combination of these. For example, in regularly spaced plantations, the removal of one row in three, with selective thinning in remaining rows, is operationally feasible except in very dense stands. This pattern allows inferior trees to be removed from residual rows. Alternate row removal is desirable in very dense stands, because this pattern facilitates access. In some cases, two adjacent rows must be removed in the first thinning to provide access. In all cases, sufficient

[24] Campbell, Dr. R., Provincial Herbicide Specialist, Pest Management Section, Forest Resources Branch, OMNR, Sault Ste. Marie, Ontario, Personal Communication.

crop trees should remain in the residual stand to form the future crop. In stands originating from natural regeneration or in irregularly spaced plantations, access must be created through the removal of strips or groups of trees (OMNR 1986d).

For both white pine and red pine, the basal area should be reduced to 23 to 25 m^2/ha in first thinnings and to 30 to 35 m^2/ha in subsequent thinnings. The net basal area increment may be reduced if stands are thinned to lower levels of residual basal area (Benzie 1977; Lancaster and Leak 1978; Chapeskie 1983; OMNR 1986d). Thinning is beneficial when the live crown-ratio decreases to 40 per cent for either species (Horton and Bedell 1960; Chapeskie 1983; OMNR 1986d).

When there is a high risk of wind, snow, or ice damage, the basal area of stands should not be reduced by more than one-third. Stands become more resistant to damage after several thinnings, because treatment stimulates development of more cylindrical boles and broader, fuller crowns. These trees have a greater ability to intercept snow, an important consideration for management of white-tailed deer.

A minimum of 250 crop trees per hectare should be selected and marked. Crop trees should not be selected until vertical differentiation of the stand has occurred and dominant and co-dominant trees are clearly identifiable. Usually, this operation is conducted between the first and second thinnings. It can be carried out before the first thinning if a selective thinning is feasible. Potential crop trees are dominant or co-dominant trees with good form and full crowns exhibiting a fine-branching habit. These trees should be well distributed throughout the stand. Innovative strategies should be developed to market small-diameter material from first thinnings

Practically all second and subsequent thinnings in white pine and red pine stands yield commercial harvests. Selective thinnings that release crop trees are recommended (Benzie 1985; OMNR 1986d; Smith and Seymour 1985). Several adjacent trees should be removed from around each crop tree (Stiell 1970). Thinning cycles of five to twenty years may be applicable, depending on thinning intensity and market conditions.

3.4.1.3 Stand Improvement

Improvement cutting generally applies to high-graded stands, mixedwood stands, and occasionally to extensively managed plantations that are pole size or larger. Defective and overmature trees of any species are removed to favour future crop trees. Thinning of potential crop trees may be a component of improvement activity, depending on vertical structure and density of the stand. Where possible, commercial operations are favoured, although this strategy often requires delaying the treatment until white pine stands are 30 to 40 years of age and red pine stands are 25 to 30 years of age. Because of its shade tolerance, white pine will respond well to release even where the trees have been overtopped for extended periods. Trees with larger, fuller crowns respond best.

White pine stands, particularly those containing a hardwood component, benefit most from improvement cutting (Stiell 1985). Improvement cutting in mixedwood stands has resulted in impressive growth and merchantable yield gains for both white pine and red pine (Stiell 1984). Results of economic analysis suggest that improvement operations in white pine and red pine stands are a wise investment (Vodak et al. 1981).

3.4.1.4 Pruning

The clipping and destruction of terminals damaged by the white pine weevil is appropriate in open-grown plantations (Robbins 1985). Understocked stands or parts of stands where crown closure is delayed should be given priority. Treatment mainly corrects stem form and encourages more rapid healing of wounds. Also, there is less risk of infection in treated stands (Brace 1971; Gross 1985b) (section 3.4.2, "Forest Protection").

Pure stands of either white pine or red pine exhibit relatively poor natural pruning. In contrast, natural pruning is often good where white pine grows in mixedwood stands (Smith and Seymour 1985). In pure, dense stands, lower branches die and are retained fo. years, especially on white pine. These provide entry points for decay fungi and result in the incorporation of loose knots in the wood (Horton and Bedell 1960), which adversely affects log grade potential. Crop trees should be pruned as soon as possible after thinning or improvement operations have been completed. Conditions favouring rapid growth are optimal at this time, and branch stubs heal over quickly (Smith and Seymour 1985; Lancaster 1984).

Ideally, operations should be carried out when stem diameter is about 15 cm in order to set a small knotty core. At this size, branches are small, healing is rapid, and pruning is less costly. Pruning of trees up to 20 cm in diameter is justifiable if they are to be retained for 20 years or more. Pruning carried out in several stages affords better control over branch size and prevents development of dead branches. Pruning height should be based on present and projected utilization standards and on economic as well as operational considerations.

Between one-third and one-half of the live crown can be removed in one operation, provided that at least 40 per cent of the total stem is maintained in live crown. Live branches greater than five centimetres in diameter should not be pruned because of high cost, slow healing, and the danger of decay infection.

Priority should be given to stands of either species growing on the best sites available. Here, pruning costs tend to be lower because of greater internodal lengths and small branch diameters. Where low-density management strategies are applied, the potential for the formation of dead branches and associated loose knots is lower. However, pruning costs may be higher because of large, mean branch diameters. The pruning of white pine has been justified in many cost/benefit studies (Lancaster 1984; Robbins 1985).

3.4.2 Forest Protection

Pest management needs to be integrated into all phases of the silvicultural system, including harvest, renewal, and maintenance. Many insects and diseases tend to be most damaging on the least productive sites. Therefore, site selection and the consideration of the biology of various potentially damaging insects, diseases, and mammals help to create a forest that is less susceptible to damage. Proper site selection and management of vegetation communities is the most important step in mitigating pest damage, and also helps to reduce the impact of other potentially damaging agents, including mice, hare, and deer. Protection strategies, in themselves, should be secondary and should be applied where there is danger of significant loss in growth, value potential, or mortality. Condition assessments need to be scheduled on a regular basis so that the status of pest problems are known, thus facilitating timely scheduling of control measures where necessary. Options available for moderating the impact of important damaging agents are discussed below. Silvicultural treatment alternatives should be explored before pesticides are used. When chemical control is the only effective means of reducing pest damage, insecticides must be applied according to OMNR Forest Resources Branch Procedure No. FR 04 10 10 PR (1987), *Aerial Application of Insecticides for Forest Management in Ontario*.

3.4.2.1 White Pine Weevil

In this guide, silvicultural controls to lessen the impact of the white pine weevil are stressed. These options have been discussed previously in section 2.3.6, "Damaging Agents." The maintenance of shade to lessen the impact of the white pine weevil is appropriate on dry sites particularly where stocking is not well controlled. A level of 40 per cent crown closure is adequate for protection (Heckman et al. 1985). Trees that grow in shaded conditions tend to have thin leaders, that are less preferred by the insect (Sullivan 1961). Also, weevils usually avoid shaded conditions for feeding and oviposition (Sullivan 1961; Wallace and Sullivan 1985) and as overwintering sites (Harman and Kulman 1969; Droska 1982).

Open planting of white pine should be avoided on dry sandy soils, because height growth is comparatively slow and stocking is difficult to control. The prevailing microclimate on these sites is often dry, and protection from associated vegetation is minimal. These conditions are optimal for weevil development. On these sites, white pine can be planted under the protection of an established nurse crop (e.g., jack pine, larch, or poplar). Alternately, white pine can be planted along with a nurse crop or it may be introduced in the next rotation. On fresh to moderately moist soils, height growth is more rapid and crown closure occurs sooner. Stocking levels are easier to control, provided that competing vegetation is controlled.

Since weevils are poor flyers, they are usually unable to reach heights of six metres or more.[25] After crown closure, the incidence of overwintering weevils is reduced and the trees are less susceptibile to weevil damage (Graham 1918; Droska 1982). As well, self-correction of the stem is better (Lancaster 1984).

[25]Retnakarin, Dr. A., Research Scientist, Great Lakes Forestry Centre, Canadian Forestry Service, Sault Ste. Marie, Ontario, Personal Communication.

The clipping and burning of leaders damaged by the weevil is appropriate in open-grown plantations. This practice may lower the risk of weevil attack because the selected, relatively small diameter laterals that remain are less preferred by the weevil. This treatment should be applied before the adults emerge. Where a reduction in population levels is expected, clipping must be carried out over the entire area to prevent re-infection from surrounding reservoir areas. Clipping can often be carried out at the same time as manual cleaning operations with minimal additional cost.

Selective ground applications with methoxychlor in the spring or the fall have been used to control the white pine weevil in Ontario (Deboo 1978; de Groot 1985). The spring treatment should be conducted before the weevils oviposit. Since weevils emerge over an extended period, they often escape the effects of this treatment and are successful in laying eggs. Therefore, this insecticide cannot be relied upon to protect specific trees. It is not a suitable protection measure in large production plantations, and should be limited to very small, high-value situations.

Applying insect growth regulators, such as benzoylphenyl ureas, early in spring, prior to oviposition, shows promise for control. The compound persists for several weeks on leaders and acts both by contact and ingestion in both sexes. Weevils are not killed, but the eggs they lay either fail to hatch or the larvae die soon after emerging. At present, the benzoylphenyls are not registered for use.[26]

3.4.2.2 Sawflies

The severity of sawfly damage in young red pine stands tends to increase as site quality decreases. Proper site selection should help to reduce the impact of this pest.

Redheaded Pine Sawfly

The redheaded pine sawfly is readily controlled by sprays containing a nuclear polyhedrosis virus. The virus is very specific to this species. Stage of development of the insect and weather conditions are critical to treatment success. The virus has the added advantage of transmission to succeeding generations (Cunningham et al. 1984).

European Pine Sawfly

A nuclear polyhedrosis virus has been developed to control this insect, but it is not registered for operational use. A selective treatment with Malathion (by ground application) when the larvae are feeding is an appropriate control measure (Rose and Lindquist 1973).

[26]Retnakarin, Dr. A., Research Scientist, Great Lakes Forestry Centre, Canadian Forestry Service, Sault Ste. Marie, Ontario, Personal Communication.

3.4.2.3 White Pine Blister Rust

White pine can be grown successfully in all blister rust hazard zones, but, as the hazard increases, site selection and control programs become more important (Gross 1985a). In summary, the following practices are appropriate and will help to minimize damage:

- reducing the abundance of the alternate hosts (gooseberry and currant) of blister rust. These plants are shade intolerant so their abundance and vigour can be reduced by maintaining a closed canopy. A closed canopy also results in a generally drier microclimate within the stand, which is less favourable to spread of the rust (Van Arsdel 1961);

- controlling lower vegetation in stand openings;

- avoiding the establishment of white pine in open-grown plantations on dry sites where stocking is difficult to control; and

- scheduling early pruning of lower branches of all white pine less than two metres in height in plantations or stands growing on moderate- to high-risk sites. Blister rust infection can be reduced by removing the lower one-third of the crown in very young stands (Van Arsdel 1964; OMNR 1987f).

3.4.2.4 Scleroderris Canker

The risk of infection and spread of this disease can be substantially reduced by not establishing red pine in depressions or frost pockets. This point is a very important consideration when selecting sites for planting red pine. Monitoring stands for scleroderris must be an integral component of all condition assessments scheduled after planting. Immature stands should be thinned so that stand and individual tree vigour are maintained. Control measures specific to the North American and European races of the disease are discussed below.

North American Race

Where an infection hazard is known to exist, inspect all new plantings in May and June. The needle-base-browning symptom is apparent at this time. Rogue out all infected trees, and either burn them or otherwise remove them from the site. If only a small number of trees is infected, inspect stands periodically, removing infected trees or branches. Only infected branches need to be destroyed or removed from the site. Lower branches should be pruned several times before the trees reach two metres in height.

Often, infection by scleroderris remains low until crown closure begins. Very close initial spacings are undesirable, since the trees cannot outgrow the disease at this stage. Crown closure may occur prior to the trees reaching two metres in height where the initial spacing is very close.

EUROPEAN RACE

Where the European strain of the causal fungus is suspected, it should be reported to the Forest Insect and Disease Survey unit (FIDS) of the Canadian Forestry Service. FIDS personnel are trained in processing quarantined material. This quarantine procedure helps to ensure that infections are confined locally. Race identification requires lab facilities, and FIDS handling ensures good sample material.

When the presence of the European race is confirmed, the recommended strategy is on-site destruction of infected materials. The burning of infected trees or tree parts is necessary. The remaining stand should be thinned in order to maintain stand and individual tree vigour. Procedures for the control of this disease are outlined in OMNR Forest Resources Branch Procedure No. FR 04 31 10 (1987), *Control of European Race of Gremmeniella abietina (Scleroderris Canker) in Ontario*.

3.4.2.5 Fomes Root Rot

Red pine is very susceptible to infection by fomes root rot. Primary infections can be controlled by chemically treating all cut stumps with dry granular borax. This treatment provides an effective barrier against infection. The disease spreads to neighbouring trees by way of root grafts. Secondary infection can be limited by removing pockets of dead and dying trees associated with known infection centres and by removing all living trees within 20 m of the outer perimeter of these pockets. This action should buffer the remaining trees from infection with a wall of dead roots. All cut stumps should be treated with borax when using this method. Procedures for the use of borax are outlined in OMNR Forest Resources Branch Procedure No. FR 04 30 10 (1983), *Borax for Control of Fomes Root Rot (Fomes annosus)*.

3.4.2.6 Red Ring Rot

Losses to red ring rot in immature stands can be minimized by avoiding unnecessary damage to the residual stand during harvesting operations. Harvest damage includes scarring of boles and damage to root systems (section 3.2, "Harvesting Considerations"), which can provide entry points for decay fungi, including red ring rot. Overmature stands should be harvested before losses become significant.

3.4.2.7 Other Damaging Agents

Damage caused by deer can be minimized by providing sufficient preferred browse to support desired population levels within the general forest area. Animal populations can be controlled by regulated hunting.

Mice damage can be minimized by controlling grass and herbaceous vegetation, which provides food and security for these animals. Damage caused by hares can be limited by disposing of slash piles and controlling competing vegetation in site preparation and tending operations.

3.5 Conversion

For the purposes of this guide, stand conversion involves the replacement of one working group with another through the application of planned silvicultural technologies. Conversion to the white pine or red pine working group should be directed towards areas that once supported productive stands of white pine and, to a lesser extent, of red pine, but are currently stocked to poplar, birch, or shrub species. These sites are classified as site class 3 (Plonski 1981) for poplar and birch, but are site class 1 or 2 for the pines. Low-quality stands of tolerant hardwoods or balsam fir can also be converted to white pine and red pine on a more limited scale. The moderately dry to fresh tills are the most suitable sites for conversion.

Conversion to the white pine or red pine working group is still in the technology development stage. Different treatments have been tried in a variety of situations. Successful conversion requires careful planning and a high level of investment in silviculture. Project planning entails the identification of candidate areas, site determination, cost analysis, and the selection of suitable harvest and renewal strategies. Conversion must not be undertaken without a commitment to planning and investment.

Conversion to either pine working group is most often achieved through the use of the clear cut silvicultural system. This system is most applicable in the conversion of stands dominated by poplar and or white birch. Conversion can also be accomplished by using the shelterwood system, and is recommended when converting to white pine where the risk of white pine weevil damage is high. The shelterwood system is most suitable in the conversion from deeper-rooted or more tolerant species such as hard maple. Refer to section 3.1, "Silvicultural Systems" for more information on the clear cut and shelterwood systems.

Certain site conditions require specific silvicultural considerations. On fresh soils, the major consideration is vegetation competition which can be intense. Conversion to either pine on these soils should not be undertaken without a commitment to competition control before and after regeneration. On dry soils, a light cover of vegetation will protect white pine from microclimatic extremes. Where the risk of weevil damage is high, red pine may be preferred over white pine with the possibility of introducing white pine in the next rotation. White pine can be established in the first rotation on these high-risk sites if a shade canopy is allowed to develop first. On exposed sites, especially where site preparation has been intense, white pine may be introduced after a protective canopy has developed over a period of one or two years.

Site preparation is required to reduce or eliminate vegetation competition, to align slash, and/or to prepare suitable planting microsites. Combinations of mechanical and chemical or chemical

and prescribed burn treatments can be used, depending on local circumstances. Refer to section 3.3.1, "Site Preparation" for more information.

Planting is required to regenerate conversion sites to white pine or red pine regardless of the silvicultural system used to harvest the site. Tending through to the free-to-grow stage is essential to ensure the successful establishment of the pines. In the case of white pine, it is desirable to retain some overhead shade to reduce the effects of the white pine weevil. Refer to section 3.3.2.3, "Planting" for more information.

Successful conversion to the white pine or red pine working group constitutes intensive forest management. These stands require tending and protection throughout the rotation to protect initial investments. Examples of conversion technologies which have been used in the OMNR's Bancroft and Bracebridge Districts are presented in Appendix VI.

Conversion from the white pine or red pine working group to the poplar or tolerant hardwood working groups is appropriate on sites where poplar or the hardwoods are productive and establishment of the pines is difficult and costly. Conversion from the pines is particularily appropriate where access is poor and distances to established markets are long. This management decision must be a conscious one that is documented in the Timber Management Plan. Reference should be made to the silvicultural guide for the designated working group for management details.

3.6 Management Intensity

Determining the intensity of management is one of the first steps in the timber management planning process. Decisions regarding management intensity are based on a combination of biological, social, and economic factors. These factors include the inherent productivity of the site; its biological requirements for regeneration; access; its proximity to local mills; the local and international markets for various wood products; available funding; and other land-use concerns.

Economic analysis provides a useful tool to assist local managers in selecting an appropriate level of management intensity and for determining the optimum series of silvicultural treatments within a given level. Procedures to evaluate silvicultural options using economic considerations have been developed by Hynard (1984).

More management options are available for white pine than for red pine. White pine tolerates a wider range of sites, and can be regenerated naturally or artificially. It has good potential for genetic improvement, and has excellent marketability for high-value products. Red pine, on the other hand, can only be regenerated artificially, exhibits low genetic variability, and has a more restricted product potential. Both species respond well to tending treatments, especially thinning and pruning, and both enjoy high market value. The level of management intensity may be affected by the susceptibility of these species to specific pest damage, which can be severe in

some situations. However, effective management techniques are available to ameliorate the impact of these damaging agents.

Four levels of investment have been described for Ontario (OMNR 1986e): extensive, basic, intensive, and elite. These levels are discussed below as they relate to the management of the white pine and red pine working groups.

Extensive

The extensive level of management is applicable to white pine on some of the driest sites on which it grows, such as dry sands on outwash plains or dry granitic ridges. White pine can be managed extensively on these low-productivity sites by modified clear cutting that leaves a seed source. Vegetative competition is very low on these dry sites, and white pine is virtually assured as long as there is a seed source. There is little organic matter to impede seedling establishment, and normal logging practices usually disturb the ground surface sufficiently to provide an adequate seedbed. These sites are climatically harsh in summer, and regeneration periods may be quite long (ten years or more).

Red pine cannot be managed extensively because of its poor ability to regenerate naturally.

Basic

The basic level of management intensity can maintain the white pine working group with low to moderate levels of investment in silvicultural treatments, but it is inappropriate for the management of the red pine working group.

White pine sites most suitable for this level of management include the moderately dry to moderately fresh sites on all site types. These sites approximate Plonski's (1981) site class 3 and low site class 2. Managing by the uniform or strip shelterwood system provides a source of seed for regeneration and shelter during the establishment period. Site preparation and tending for vegetation control, especially during the establishment period, may be necessary on the more productive sites.

Intensive

The intensive level of forest management requires a higher level of investment in silvicultural treatments. For example, site preparation may be followed by planting, cleaning, thinning, and pruning treatments. Yields are expected to be greater for this level of investment than for the basic level of management or for natural, unmanaged stands.

Intensive management is appropriate for accessible stands of white pine and red pine growing on sites of moderate to high timber production potential. Such sites include the deeper till, outwash, and, to a lesser extent, lacustrine sites. Vegetative competition is a major factor in the management of these sites and can be accomplished by appropriate site preparation and tending

operations. Planting is required for the establishment of both pines. On the better sites, thinning and pruning can increase individual tree value and stand productivity. Pest management is essential.

Elite

The elite level of management is characterized by planting genetically improved stock on the more productive pine sites. This highest level of investment must be protected by intensive maintenance practices throughout the rotation. While the level of investment is high, the yield and value returns are expected to exceed all other levels of management intensity.

White pine is suited to this level of management because of its potential for planned genetic improvement and high-value productivity. A limited quantity of genetically improved white pine stock should become available during the next few years. Some rust-resistant stock is already being produced at Orono nursery.

Elite management of white pine is best practiced on fresh sandy sites (site class 1 or high site class 2 [Plonski 1981]).Vegetative competition must be controlled through site preparation and various tending treatments. Individual tree and stand productivity and value can be enhanced by appropriate thinning and pruning treatments.

Elite management of red pine is not viable because its low genetic variability renders it unsuitable for inclusion in Ontario's tree improvement program.

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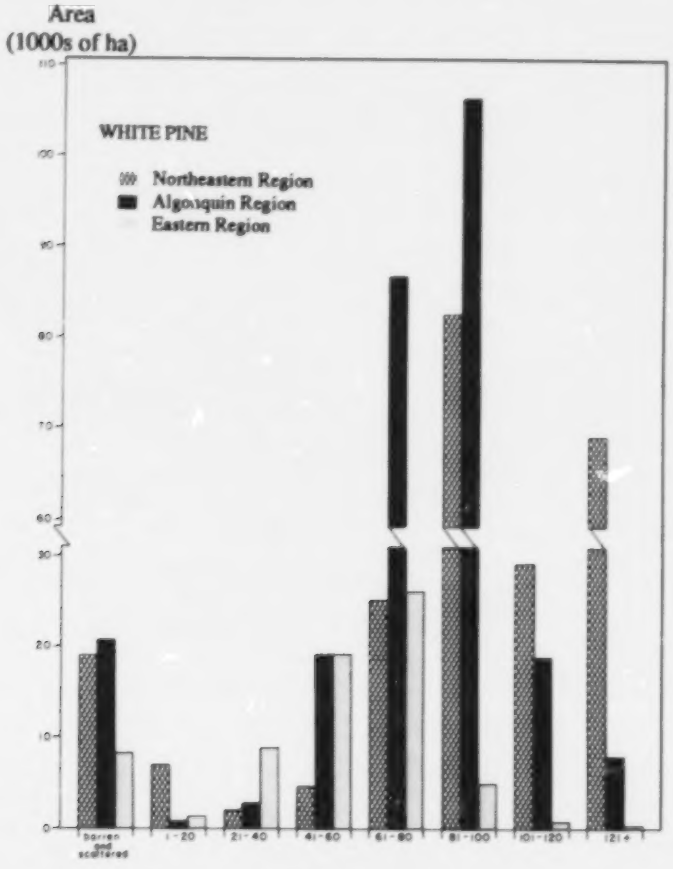
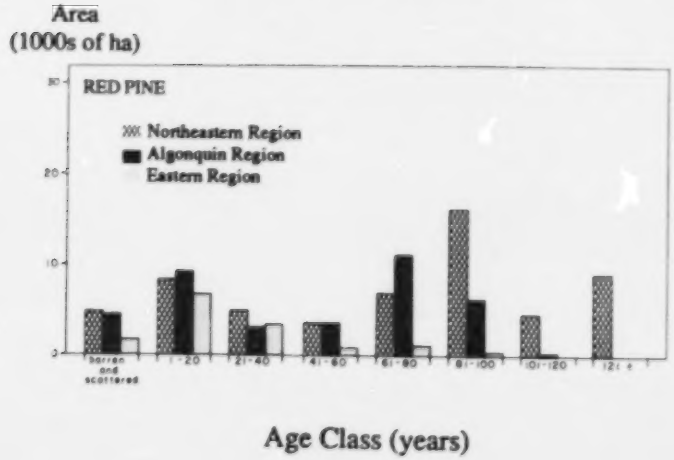
APPENDIX I

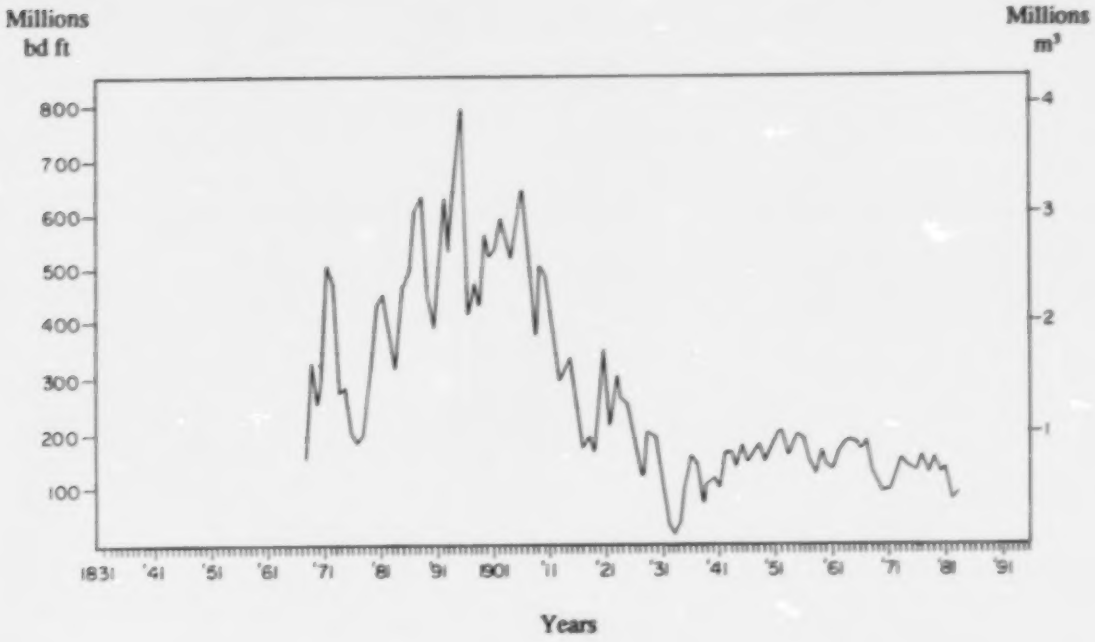
Age-Class Distribution of the White Pine and Red Pine Working Groups in OMNR's Algonquin, Eastern, and Northeastern Regions (from OMNR [1986f])





APPENDIX II

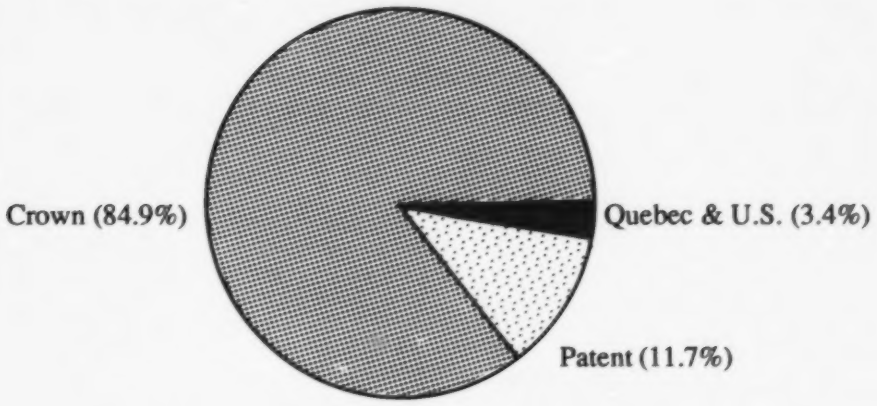
Historical Harvest of White Pine and Red Pine in Ontario (from Aird [1983])



APPENDIX III

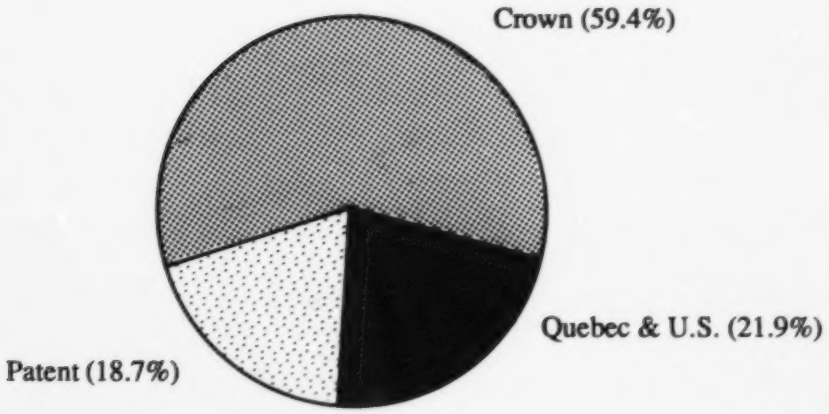
Average Annual White Pine and Red Pine Roundwood Receipts by Source for the Period 1982 to 1986 for OMNR's Algonquin and Northeastern Regions (derived from individual mill statistics, Timber Sales Branch, OMNR)

NORTHEASTERN REGION



Total Average Roundwood Receipts = 471,148 m^3

ALGONQUIN REGION



Total Average Roundwood Receipts = 470,877 m^3

APPENDIX IV

Biological Rotation Ages for White Pine and Red Pine in OMNR's Northeastern Region for Site Regions 4200 and 5200 (provided by Northeastern Region, OMNR)

Site Region	Species	Site Class	Age (Years)	MAI (m^3/ha)
4200	White pine	I	110	3.5
		II	100	2.1
	Red pine	I	120 *	5.3
		II	120 *	3.1
		III	140	1.1
5200	White pine	I	70	4.8
		II	80	3.3
	Red pine	I	70	7.4
		II	80	4.1
		III	100 *	2.4

*MAI (mean annual increment) is not at its peak

APPENDIX V

An Example of Silvicultural Ground Rules for the White pine and Red Pine Working Groups in Ontario

This appendix provides an example of actual silvicultural ground rules for the management of the white pine and/or red pine working groups in use on a specific Crown Management Unit in Ontario. The site descriptions are based on the Forest Resources Inventory (FRI) site classes developed by Plonski (1981). The use of FRI site classes provides a basic approach to site classification where a more specific system is not available, since the height/age relationships on which FRI site classes are developed is one measure of site productivity. However, where specific site descriptions are available, they should be used in the development of silvicultural ground rules. A discussion of "site" as it relates to white pine and red pine is contained in section 2.2, "Site" and can form the basis for developing site specific classifications for silvicultural ground rules.

FRI* Working Group: Pw*
FRI Site Class: X,1,2,3
Desired Working Group/Forest Unit: Pw

Silvicultural System	Harvest Method	Renewal Treatments	Maintenance Treatments	Stocking Standards		
				Desired Working Group/Forest Unit Species		Acceptable Species
				Minimum	Desired	Minimum
Uniform shelterwood R = 100 yrs	Two-stage cut The first cut is for regeneration and occurs at 80 years 40 to 60 per cent of existing stand is removed with mainly Pw remaining The second cut is for harvest at 100 years or when regeneration is free-to-grow	Mechanical site preparation after first cut to expose mineral soil and to prepare site for natural regeneration, or planting of bareroot or container stock where hardwood competition is expected to be light but slash conditions and residual stems are heavy Chemical site preparation using 2,4-D, Vision, or Velpar or other approved herbicide to control broad-leaved competition for subsequent natural or artificial regeneration as above (a combination of mechanical and chemical site preparation methods may be used in sequence or simultaneously where competition and/or slash conditions are extreme) Prescribed burn to reduce the organic layer and eliminate hardwood competition to prepare the site for subsequent natural or artificial regeneration as above Suitable for use on sites with distinct fire boundries, or on sites with extreme competition conditions which mechanical or chemical methods cannot control. Where bareroot stock is used, 3 + 0 Pw established at 1.5 m x 1.5 m spacing Containers established at the same spacing on suitable sites	Manual or chemical cleaning may be required between the first and second harvest cut, or after the second cut, to release pine regeneration from grass, brush, or hardwood competition Pre-commercial and commercial selective thinnings may be required before the first harvest cut (ages 20 to 60 years) to maintain stand vigour and stocking, or to reduce or remove the hardwood component Maintain a basal area of 25 to 30 m^2/ha of stems greater than 10 cm DBH Selection and pruning of 350 crop trees per ha to a height of 5.2 m should be conducted in conjunction with first non-commercial thinning Stump treatment with Borax to prevent infection by *Fomes annosus* Reduction of weevil damage through maintenance of a maximum of 60 per cent full sunlight Protection from white pine blister rust through risk evaluation of site prior to regeneration and removal of infected branches or stems later on	> 40 % Pw	> 80 % Pw, Pr, Sp, Or, Mh, Aw	> 60 % Pw, Pr, Sp, Or, Mh, Aw, at 8 yrs

FRI Working Group: Pr
FRI Site Class: 1,2
Desired Working Group/Forest Unit: Pr

Silvicultural System	Harvest Method	Renewal Treatments	Maintenance Treatments	Stocking Standards		
				Desired Working Group/Forest Unit Species		Acceptable Species
				Minimum	Desired	Minimum
Clear cut (plantation) R = 70 yrs		Mechanical site preparation where competition is expected to be light but slash conditions or residuals are heavy To expose mineral soil to prepare site for artificial regeneration Chemical site preparation, either broadcast or in bands, may be necessary in old-field situations where grass and brush competition is heavy A combination of mechanical or chemical site preparation may be used simultaneously or in sequence where competition is extreme Regenerate site using 2 + 0 bareroot nursery stock at 2.4 m x 2.1 m spacing	Pre-plant chemical tending with simazine or Velpar on old-field sites Manual or chemical cleaning to reduce competition to bring plantation to free-to-grow status. Pre-commercial and commercial row thinnings when stand reaches crown closure to maintain a basal area of 25 to 30 m^2/ha Pruning of 350 crop trees per ha to height of 5.2 m when first thinning occurs in areas of high recreational use to enhance aesthetics and reduce fire hazard Stump treatment with Borax to prevent infection by *Fomes annosus* Protection of young (<10 yrs) plantation from sawflies	> 60 % Pr	> 80 % Pr	> 80 % at 5 yrs.

FRI Working Group: Bf
FRI Site Class: X,1,2,3
Desired Working Group/Forest Unit: Pw, Sw, Bf

Silvicultural System	Harvest Method	Renewal Treatments	Maintenance Treatments	Stocking Standards		
				Desired Working Group/Forest Unit Species		Acceptable Species
				Minimum	Desired	Minimum
Clear cut R = 50 yrs or as stand encountered in the course of other operations		Mechanical site preparation where hardwood competition is light but slash and/or residual stems are heavy To expose mineral soil and prepare site for artificial regeneration using bareroot or container stock of desired species Chemical site preparation using 2,4-D, Vision, or Velpar or other approved herbicide to control broad-leaved competition for subsequent artificial regeneration as above Prescribed burning to reduce heavy, advance, non-merchantable Bf regeneration on suitable sites	Refer to tending prescriptions for desired working groups	> 40 % Pw, Sp Bf	> 80 % Pw, Pr, Sp, Or, Mh	> 60 % Pw, Sp, Bf, Or, Mh at 8 yrs

FRI Working Group: Bf
FRI Site Class: 3
Desired Working Group/Forest Unit: Pw, Or, Mh

Silvicultural System	Harvest Method	Renewal Treatments	Maintenance Treatments	Stocking Standards		
				Desired Working Group/Forest Unit Species		Acceptable Species
				Minimum	Desired	Minimum
Clear cut or clear cut with standards R = 60 yrs		On poorer site classes, a conversion to a more suitable species may be considered Regeneration may be natural or aritificial depending on the suitable species Where stems of desired working group exist they will be retained to provide seed source and shelter for regeneration If Pw is to be established, refer to guidelines for Pw If Or or Mh is preferred, scarification for natural or artificial seeding may be undertaken	Pw, Or, Mh For conversion to Pw, refer to guidelines for Pw For conversion to Or or Mh, manual cleaning is required to release desired regeneration from brush competition	> 40 % Pw, Or, or Mh	> 70 % Pw, Or, or Mh	> 60 % Pw, Mh, Or, Bw, Po, Sw, at 5 yrs

*FRI=Forest Resources Inventory

*Pw = White Pine
Pj = Jack Pine
Sw = White Spruce
S = Spruce
Or = Red Oak
Mh = Hard Maple
Pr = Red Pine
L = Larch
Sr = Red Spruce
B = Balsam Fir
Aw = White Ash

Source: Carleton Place District

APPENDIX VI

Examples of Conversion Technologies Used in the OMNR's Bancroft and Bracebridge Districts

Bancroft District

Sites

- depth: shallow to moderately deep
- texture: fine to very fine sands
- moisture regime: moderately fresh to moderately moist

Cover Types

- old cutovers stocked to shrub species
- poplar and poplar/pine clear cuts where the softwood component ranged from 0 to 40 per cent
- balsam fir budworm-damaged stands where little or no salvage occurred

Observations

- early survival of white pine regeneration is poor where raspberry competition is severe
- raspberry competition is severe on fresh sites where site preparation has mixed the organic layer with the mineral soil; drier sites and bare mineral soil have very little raspberry competition
- early survival of white pine regeneration is good in poplar suckers; poplar suckers thin themselves rapidly and their height growth slows appreciably allowing adequate height growth of white pine seedlings; blister rust is less of a problem here than where shrub competition is intense
- white pine trees planted on sites with heavy poplar suckering will exceed 60 cm in height after four growing seasons and 175 cm after seven growing seasons
- tending may be required before age 10 years to prevent whipping damage from poplar suckers
- hot burns reduce raspberry and shrub growth and encourage poplar suckers; light burns do the opposite
- burns in early June will fill with poplar suckers one metre tall at the end of the growing season; burns in late July sucker very lightly or not at all in the same season
- planting immediately after a spring burn is not recommended as the blackened seedbed gets very hot; this condition, combined with periods of low precipitation, can cause high mortality; wait one year before planting white pine
- a hot, early to mid-season burn followed by spring planting appears to be the most encouraging technique to date
- on drier sites, intensive use of Young's teeth is recommended

Bracebridge District
Sites/Stands

- sandy soils (sands, sandy loams, loamy sands) of outwash or glacial origin as follows:

  - nutrient-poor soils which cannot grow high-quality hard maple or yellow birch, but can support low-quality stands of these species. Where the moisture regime is fresh to moderately dry, these sites usually produce good stands of white pine. Typically, these sites originally supported productive white pine stands, but are now occupied by first generation heavy hardwoods.

  - fresh to dry soils which are currently occupied by intolerant hardwoods or mixtures of intolerants (poplar and/or birch) and white pine and/or white spruce. Fresh sites can be converted to white pine. Drier sites or coarser soils can be converted to red pine. The poplar (usually trembling aspen) is normally of very poor quality and is consioered "off site"

Harvest Method

- to convert to white pine: uniform shelterwood system; maintain approximately 50 per cent overhead canopy. Removal cut in winter season; or kill residual overstory to avoid damage to young pine. Where the risk of white pine weevil is high, use two removal cuts to prolong shading

- to convert to red pine: clear cut

Site Preparation

- light blade scarification to remove and align debris, remove existing vegetative competition, and remove dormant seeds (especially raspberry) in the organic layer

- herbicide application during mid- to late summer in the year after scarification, to remove resprouted vegetative competition and new germinants

Planting

- plant in the spring following herbicide. To convert to white pine use 1+2 or 3+0 bareroot or two year old container stock. To convert to red pine use 3+0 or two year old container stock

- where scarification and herbicides are used, tending may be required, but usually not until the fifth growing season after planting

- if scarification only is used, tending may be required on the drier sites and will definitely be required on the fresh, richer fine textured soils, usually before the fifth growing season if height growth increment is to be maintained

- where there is a high risk for white pine blister rust infection, prune the lower boles of a sufficient number of crop trees at year five (if > 3 % lethal cankers exist)

- where weevilling occurs, clip white pine leaders in July and destroy, starting when infection is light

GLOSSARY OF SCIENTIFIC NAMES

COMMON NAME	SCIENTIFIC NAME
ash	*Fraxinus* spp.
aspen	*Populus tremuloides* Michx. and/or *Populus grandidentata* Michx.
aster (lar ge-leaved)	*Aster macrophyllus* L.
bald eagle	*Haliaeetus leucocephalus* (Linnaeus)
balsam fir	*Abies balsamea* (L.) Mill.
beaked hazel	*Corylus cornuta* Marsh.
beaver	*Castor canadensis* Kuhl
beech	*Fagus grandifolia* Ehrh.
birch	*Betula* spp.
black bear	*Ursus americanus* Pallas
black-throated green warbler	*Dendroica virens* (Gmelin)
blackburnian warbler	*Dendroica fusca* (Muller)
blue jay	*Cyanocitta cristata* (Linnaeus)
blueberry	*Vaccinium* spp.
bracken fern	*Pteridium latiusculum* (Desv.) Hieron.
budworm (eastern spruce)	*Choristoneura fumiferana* (Clem.)
bunchberry	*Cornus canadensis* L.
cedar (white)	*Thuja occidentalis* L.
cherry	*Prunus* spp.
chipmunks	*Tamias* spp., *Eutamias* spp.
clay-coloured sparrow	*Spizella pallida* (Swainson)
clover	*Trifolium* spp.
Cooper's hawk	*Accipiter cooperii* (Bonaparte)
crow	*Corvus brachyrhynchos* Brehm
currant	*Ribes* spp.
dogwood	*Cornus* spp.
eagles - see bald eagle,	
elderberry	*Sambucus* spp.
European pine sawfly	*Neodiprion sertifer* (Geoff.)
fir - see balsam fir	
fisher	*Martes pennanti* (Erxleben)
fomes root rot	*Heterobasidion annosum* (Fr.) Bref.
fox (red)	*Vulpes vulpes* (Linnaeus)
golden eagle	*Aquila chrysaetos* (Linnaeus)
gooseberry	*Ribes* spp.
goshawk (northern)	*Accipiter gentilis* (Linnaeus)
grasses	*Gramminae* spp.
grosbeak (evening)	*Hesperiphona vespertina* (Cooper)
hard maple (sugar maple)	*Acer saccharum* Marsh.
hare	*Lepus* spp.

Glossary continued

Common Name	Scientific Name
hemlock	*Tsuga canadensis* (L.) Carr.
heron (great blue)	*Ardea herodias* Linnaeus
Himalayan pine	*Pinus griffithii* McClel.
jack pine	*Pinus banksiana* Lamb.
larch	*Larix* spp.
largetooth aspen	*Populus grandidentata* Michx.
long-eared owl	*Asio otus* (Linnaeus)
lynx	*Felix lynx* (Linnaeus)
maianthemum	*Maianthemum canadense* Desf.
maple	*Acer* spp.
martin	*Martes americana* (Turton)
mice	*Napaeozapus* spp., *Peromyscus* spp., *Zapus* spp.
mink	*Mustela vison* Schreber
moose	*Alces alces* (Linnaeus)
mountain maple	*Acer spicatum* Lam.
Norway spruce	*Picea abies* (L.) Karst.
osprey	*Pandion haliaetus* (Linnaeus)
otter	*Lutra canadensis* (Schreber)
peregrine falcon	*Falco peregrinus* Tunstall
pine	*Pinus* spp.
pine siskin	*Carduelis pinus* (Wilson)
pine warbler	*Dendroica pinus* (Wilson)
polytrichum moss	*Polytrichum* spp.
poplar	*Populus* spp.
porcupine	*Erethizon dorsatum* (Linnaeus)
purple finch	*Carpodacus purpureus* (Gmelin)
rabbit	*Sylvilagus* spp.
rasberry	*Rubus* spp.
red crossbill	*Loxia curvirostra* Linnaeus
red maple	*Acer rubrum* L.
red oak	*Quercus rubra* L.
red pine	*Pinus resinosa* Ait.
red ring rot	*Phellinus pini* (Brot. :Fr.) A. Ames
red spruce	*Picea rubens* Sarg.
red-tailed hawk	*Buteo jamaicensis* (Gmelin)
redheaded pine sawfly	*Neodiprion lecontei* (Fitch)
ruffed grouse	*Bonasa umbellus* (Linnaeus)
sawflies	*Neodiprion* spp.
scleroderris canker	*Ascocalyx abietina* (Lagerb.) Schapfer-Bernhard
Scots pine	*Pinus sylvestris* L.

Glossary continued

Common Name	Scientific Name
serviceberry	*Amelanchier* spp.
sharp-shinned hawk	*Accipiter striatus* Vieillot
snowshow hare	*Lepus americanus* Erxleben
spruce grouse	*Dendragapus canadensis* (Linnaeus)
squirrels (red)	*Tamiasciurus hudsonicus* (Erxleben)
(flying)	*Glaucomys sabrinus* (Shaw)
sweetfern	*Comptonia peregrina* (L.) Coult.
trembling aspen	*Populus tremuloides* Michx.
white ash	*Fraxinus americana* L.
white birch	*Betula papyrifera* Marsh.
white pine	*Pinus strobus* L.
white pine blister rust	*Cronartium ribicola* J.C. Fischer
white pine weevil	*Pissodes strobi* (Peck)
white spruce	*Picea glauca* (Moench) Voss
white-tailed deer	*Odocoileus virginianus* (Zimmermann)
willows	*Salix* spp.
winter green	*Gaultheria procumbens* L.
woodcock	*Scolopax minor* Gmelin
yellow-rumped warbler	*Dendroica coronata* (Linnaeus)

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